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FEBRUARY 2006

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PROJECTS and FEATURES

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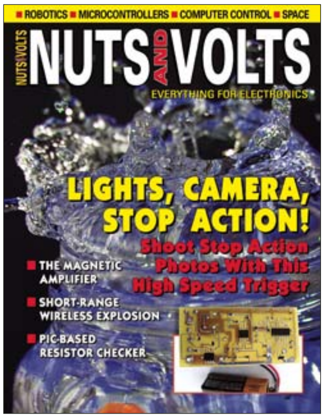

COLUMNS

DEPARTMENTS

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READER FEEDBACK

PATENT PROBLEM REVISITED

In your Reader Feedback, the short comment by T. Tofte called "Patent Problem" telling the history of the FET, a book called *Designing With Field-Effect Transistors* by Siliconix, Inc., revised by Ed Oxner, page 2 shows a partial reproduction of a patent Jan. 28, 1930 (1,745,175) by Julius Edgar Lilienfeld of Brooklyn, NY on an early Field Effect Transistor.

Ronald Robbins, El Cajon, CA

WRITER NOT RIGHT

Imagine my horror at discovering a series of math errors (all based on the original error) in my recent Let's Get Technical column. Here are the corrections. So sorry ... I am usually quite picky about checking my work.

James Antonakos, Writer

*Switching to units of bits, we have 26*8 = 208 bits of field information in each frame. The way Ethernet is designed, there is always an idle time period after each transmitted frame. This is called the interframe gap, and it corresponds to 96 bits worth of time. So, when transmitting an Ethernet frame, we use 208 bits for field information and 96 bits (96 bit times) for the interframe gap, giving 304 bits. Let us call this the overhead. If we transmit nothing but 72-byte minimal-length Ethernet frames for an entire second, we will be able to clock out 14,880 complete frames using 10 Mbps Ethernet (100 nanoseconds per bit). Now imagine how many bits are involved when we multiply 14,880 frames by the overhead of 304 bits per frame. Specifically, we are talking about 4,523,520 bits. That is 45% of our 10,000,000 bit bandwidth. That leaves almost 5,500,000 bits for carrying data each second.*

NO END IN SIGHT?

It didn't register in November, but in reading the December issue and realizing that I was flipping pages backwards after each article — asking, is this really the end? — it struck home. That bright NV at the end of each article was really very helpful. Come on guys, if it ain't broke, don't fix it !!!

Dick Greet, Rye, CO

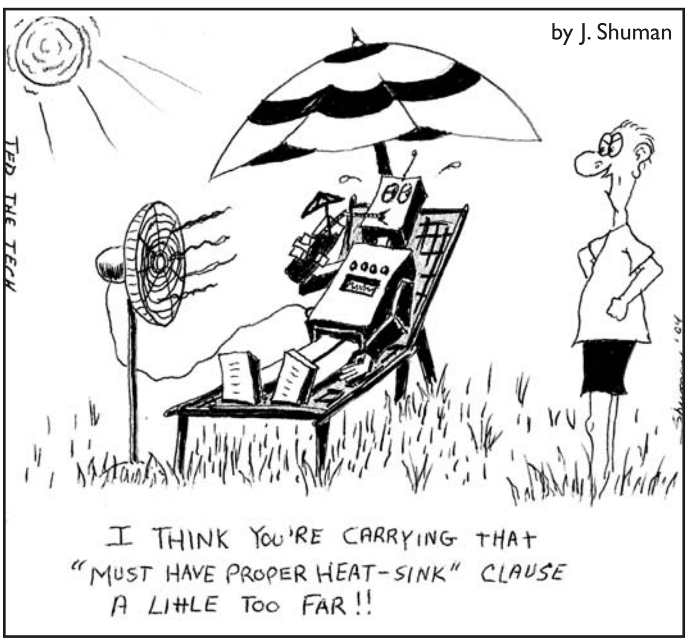
ON THE BRIGHTER SIDE ...

Never mind those soreheads ... In The Trenches has been one of my favorite columns, along with the tech answers and "Tech-newlogy." And as for the layout, while it may actually have slightly less print space, it's more readable (which I'm sure was the intent).

The only complaint I have is the pages makes photocopying harder — in the January '06 issue, I saved so much stuff, I just pulled the pages and rendered it almost worthless for passing on.

Eric Jones

Continued on page 31



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TECH KNOWLEDGEY 2006

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGIES

FUSION IGNITION A STEP CLOSER

PHOTO COURTESY OF LAWRENCE LIVERMORE NATIONAL LABORATORY.

■ The National Ignition Facility, with its 192 laser beamlines focused on a tiny target, will be the world's largest laser project when completed, currently scheduled for 2009.

Researchers at Lawrence Livermore National Laboratory (www.llnl.gov) reported conducting some successful laser experiments at the National Ignition Facility (NIF), validating key computer simulations and theoretical projections relevant to the plasma and X-ray environment necessary to achieve ignition ("ignition" being the term used for starting up a controlled nuclear fusion event). In the process, a tiny gold-plated cylinder called a "hohlraum" holds a deuterium-tritium fuel capsule in the target chamber, where the energy from 192 high-powered lasers is converted to thermal x-rays. The x-rays heat and ablate the plastic surface of the ignition capsule, causing a rocket-like pressure on the capsule and forcing it to implode and ignite, after which is produces a burst of energy that is greater than used to create it.

The NIF is a 10-story building in which 192 laser beams can be focused on a tiny target inside a 30-foot diameter aluminum-lined chamber. Eight beams have been commissioned so far. When fully operational (currently scheduled for mid-2009), NIF will be used to study and, presumably, achieve ignition, which so far has never been achieved under controlled conditions in a laboratory setting.

In the recent experiment, four beams were fired into various sized hohlraums for two nanoseconds, creating pulses of about eight trillion watts. Although no attempt was made to create ignition, the researchers claim that, by extrapolation, it is clear that the goal is achievable when the full complement of lasers is in place and able to apply 1.8 million joules of laser energy and 500 terawatts of power.

INSB TRANSISTORS DEMONSTRATED

For a couple decades now, designers and journalists alike have been fretting about how long Moore's Law can be extended. (As you probably recall, Gordon Moore, cofounder of Intel, predicted in 1965 that the number of transistors per square inch on an IC would double every year. The reality has been about every 18 months, but that is not much less amazing.)

In any event, Intel (www.intel.com) has now announced development of a prototype of a new, ultra-fast, very low-power transistor that could keep Moore an honest man for a few more decades. Researchers from Intel and QinetiQ (www.qinetiq.com) have jointly demonstrated an enhancement-mode transistor that uses indium antimonide (InSb) to conduct electrical current. Apparently, the device provides 50 percent higher performance while using only one tenth as much power as existing designs.

Although this is not the first transistor to use InSb channels, this one, with a gate length of 85 nm, is the smallest ever and can operate on only about 0.5 V. No one is speculating about when the devices will be available for production, but the impetus is there, as the result would be much better performance, less heat, and longer battery life in mobile devices.

COMPUTERS AND NETWORKING

HAND-CRANKED LAPTOPS UNDER DEVELOPMENT

It's an ugly shade of green, is powered by cranking it up, and will sell for only $100. It looks like a toy because, well, for the most part it is — at least, it is specifically designed for children. And yet, if Nicholas Negroponte, founding chairman of MIT's Media Laboratory (www.media.mit.edu), has his way, up to 100 million children in developing countries will be getting them for free through the One Laptop Per Child (OLPC) Foundation, a nonprofit group organized by Media Lab faculty but totally

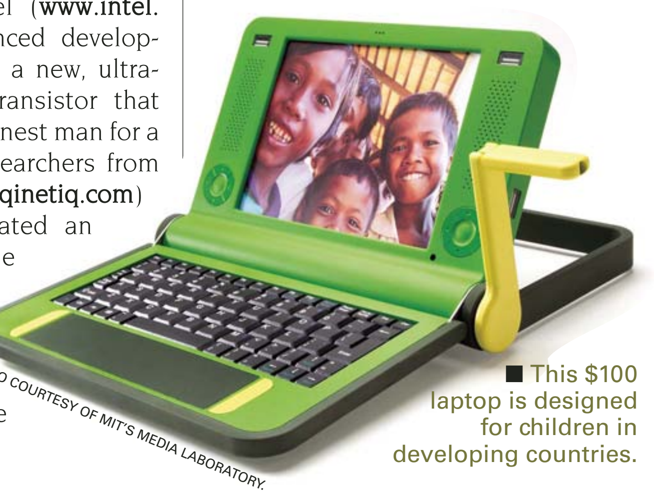


PHOTO COURTESY OF MIT'S MEDIA LABORATORY.

■ This $100 laptop is designed for children in developing countries.

separate from MIT. Its members are Advanced Micro Devices (AMD), Brightstar, Google, News Corporation, Nortel Networks, and Red Hat.

While the machines are still under development, the concept is for a WiFi-enabled, Linux-based computer that runs at 500 MHz, comes with 1 GB of memory, and sports a 1 Mpixel LCD display. The distribution plan calls for ministries of education to buy them in huge quantities and then hand them out in their own counties. Discussions have already been conducted with representatives of China, Brazil, Thailand, and Egypt. The minimum order will be 1 million units, so both manufacturing and distribution are problems that will have to be solved.

Even so, current plans are to begin building them when 5 to 10 million have been ordered, with some available by the end of this year or early in 2007. Not everyone is gung-ho on the idea, though. Intel's chairman, Craig Barrett, for example has dismissed it as a gadget that, being less functional than a normal PC, may not find wide acceptance. Time will tell.

CHEESE FOR YOUR COMPUTER

This month's nomination for the worst new product concept is the Fundue™ USB fondue set. Yes, that's right. The folks at Think Geek are offering a fondue appliance that is powered via your machine's USB port. Because of the limited power that you can draw from the connection, the device so far can be used only for melting things like cheese and chocolate, but when USB 3.0 comes into being, you'll be able to make deep fried things, too. You can pick one up for $29.99 at **www.thinkgeek.com** Will your keyboard still work when it's covered with gooey cheese? It will only take a few minutes to find out. Maybe next someone will come up with a crock pot for your digital camera.

3.89 MILLION DOMAIN NAMES FLAWED

Late last year, the House Subcommittee on Courts, the Internet, and Intellectual Property asked the General Accounting Office (GAO) to do a study of the accuracy of domain name listings and their contact information. Currently, you can look up such information using the Whois database from various locations (e.g., **www.networksolutions.com/whois/**). Based on test results, GAO estimates that 2.31 million domain names (5.14 percent) have been registered with patently false data — data that appeared obviously and intentionally false without verification against any reference data — in one or more of the required contact information fields. It also found that 1.64 million (3.65 percent) have been registered with incomplete data in one or more of the required fields. In total, we're looking at about 3.89 million domain names (8.65 percent) with at least one instance of patently false or incomplete data in the required Whois contact information fields.

At last report, the Department of Commerce and the Internet Corporation for Assigned Names and Numbers (ICANN) have implemented some new rules that require registrars to investigate reported inaccuracies, and ICANN will "continue assessing the operation of the Whois service and to implement measures to secure improved accuracy of data." In the meantime, don't be surprised if a Whois search doesn't do you much good in trying to track down spammers.

CIRCUITS AND DEVICES

POWER MOSFETS GIVE IMPROVED PERFORMANCE

NEC Electronics America, Inc., has introduced a series of power MOSFETs, representing the newest member of its line of power management devices (PMDs). The NP Series features a combination of trench technologies and advanced packaging that results in low leakage current and enables a lower on-state resistance of 1.4 milliohms (typical). The units are designed for markets requiring efficient power management and high current capability, such as automotive and low-voltage motor controls, DC/DC converters, and uninterruptible power supplies. The first device in the series, the NP110, is available now.

By combining the company's UMOS-4 process technology with a trench configuration, NEC Electronics has increased the MOSFET's cell density to better than 180 million cells per square inch. The process reduces the size of the trenches and other structures with an ultra-fine 0.25-micron design rule. In addition, by fabricating MOSFET structures along the sides of the trenches, designers can reduce the amount of silicon space required. The devices are available in TO-263 and TO-252 packages. The price starts at about $1.85 in manufacturing quantities.

CELL PHONE DESIGNED FOR CHILDREN

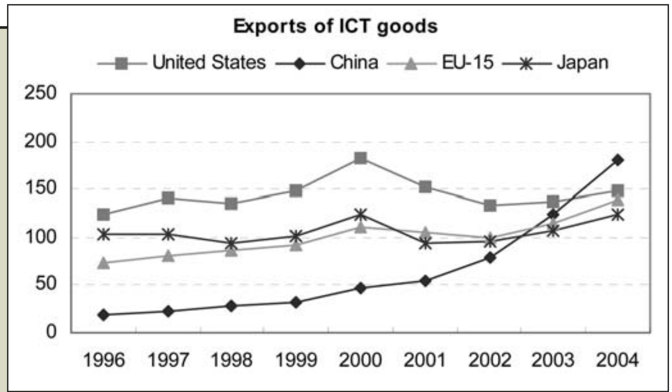
If your cell phone bills aren't high enough, and you have offspring between the ages of 6 and 12, a solution is offered by EasyCall Cellular (**www.easycallcellular.com**). Promoted as a "safety tool designed to give assurance to both parents and kids," the Firefly™ is a simplified phone that employs only five keys. Kids can contact their parents by pressing the mom or dad speed-dial keys. They can program up to 20 phone numbers into the phone's speed-dial memory, and they can also program the phone so that it accepts calls only from specified callers. It includes caller ID

PHOTO COURTESY OF CINGULAR WIRELESS.

■ The Firefly cell phone is designed specifically for children.

INDUSTRY AND THE PROFESSION

CHINA BECOMES WORLD'S ICT EXPORT LEADER



■ Exports of ICT goods, billions of US$, in current prices. Note that EU data exclude intra-EU trade. Source OECD database.

According to a report recently issued by the Organization for Economic Co-operation and Development (OECD, www.oecd.org), China overtook the United States in 2004 to become the world's leading exporter of information and communications technology (ICT) goods such as mobile phones, laptop computers, and digital cameras. China exported $180 billion worth of ICT goods in 2004, compared with US exports in the same category valued at $149 billion. In 2003, the US led with exports of ICT goods worth $137 billion, followed by China with $123 billion.

The data shows a shift toward more trade between China and other Asian countries, with a corresponding decline in ICT imports to this region from the European Union (EU) and the US. To manufacture laptops and advanced mobile phones, China previously relied on importing electronic components from the EU and US, but they are now also being increasingly sourced from other Asian countries, including Japan (18%), Taipei (16%), Korea (13%), and Malaysia (8%).

China is the single largest exporter of ICT goods to the US, supplying 27% of all its imports of these goods in 2004, up from only 10% in 2000. Its ICT trade surplus with the US stood at $34 billion in 2004 and with the EU at $27 billion.

and a 911 key.

You can get one for $99 from Target (www.target.com) and you keep it going with prepaid air time cards. Or, you can sign up for the "On-the-Fly" program from Opex Wireless (www.opexwireless.com) which will run you 25 cents per day for an access charge, 9.9 cents per call, and 9.9 cents per minute. The Firefly is also available through Cingular (www.cingular.com) reportedly for free with a two-year contract.

KEEPING TRACK OF PETS

In case you missed it, Schering-Plough operates the HomeAgain® Pet Recovery Service (www.homeagainid.com), which is a national pet ID microchip database. The service has actually been around since 1995, and it claims that approximately 7,000 lost pets are recovered every month using its technology, and that more than three million employ it.

The somewhat queasy part is that it involves implanting a microchip into your dog or cat. Then, if the critter gets lost and shows up in a vet's office, and if the vet happens to have one of the HomeAgain hand-held scanners, he can check for the implant and ultimately identify Rover as being your pet (or animal companion, if you live in San Francisco). Of course, he might be able to accomplish the same thing just by reading the tag on the animal's collar, but how high-tech is that?

The latest news from the company is that it is now offering new scanners that can detect all microchips that use the 125 kHz band, including those from companies that market an encrypted chip that previously could not be read by their equipment. The new scanners will also detect the 134 kHz microchips (ISO chips) that are commonly used outside of the United States. For $68.50, you get the microchip, implantation by a vet near you, a collar tag with a unique pet ID, 24/7 recovery services, and related Internet assistance. And, no, the device is not presently approved for use in Uncle Herbert, even if he does keep wandering off at night. **NV**

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KPC-S20PHEX4	- 1/3" B/W Micro-Cased Camera - 4.3mm Super-Cone Pin-Hole Lens - ***600 TVL of Super High Resolution*** - ***0.0003 Super Low Lux*** - ***ExView Sony CCD Chip***	**$129.95**

KPC-S20P3	- 1/3" B/W Micro-Cased Camera - 420 TVL of High Resolution - 3.7mm Flat Pin-Hole Lens, 0.05 Lux	**$69.95**
KPC-S20CP3	- 1/4" Color Micro-Cased Camera - 380 TVL of Resolution - 3.7mm Flat Pin-Hole Lens, 1.0 Lux	**$89.95**
KPC-S20PHEX3	- 1/3" B/W Micro-Cased Camera - ***600 TVL of Super High Resolution*** - 3.7mm Flat Pin-Hole Lens, 0.0003 Lux - ExView Sony CCD Chip	**$119.95**

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KPC-S20CB	- 1/4" Color Micro Cased Camera - 380 TVL of Resolution - 3.6mm Lens with 1.0Lux	**$84.95**
KPC-S20BHEX	- 1/3" B/W Micro Cased Camera - ***600 TVL of Super High Resolution*** - ***3.6mm Lens with 0.0003 Super Low Lux*** - ***ExView Sony CCD Chip***	**$109.95**

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Actual Images May Vary

Q&A

WHAT'S UP:

The past months saw a flurry of questions about batteries, and a lot of interest in Sudoku.

- ✔ Two battery charger circuits.
- ✔ All about LEDs.
- ✔ Audio power booster.
- ✔ IR remote control repeater.

■ WITH TJ BYERS

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

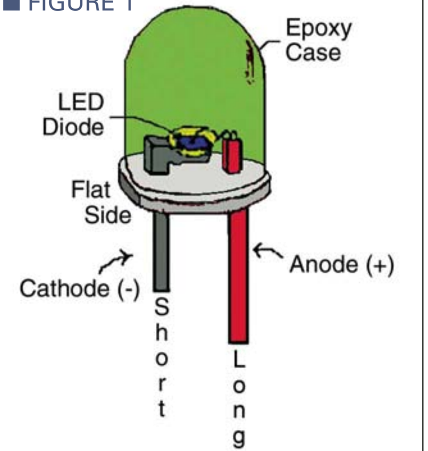
Feel free to participate with your questions, comments, or suggestions.

You can reach me at: **TJBYERS@aol.com**

Wavelength (nm)	Color	Forward Voltage	LED Material
385	Ultraviolet	3.8	GaN, InGaN, or SiC
395	Ultraviolet	3.8	GaN, InGaN, or SiC
405	Violet	3.8	GaN, InGaN, or SiC
430	Blue	3.8	GaN, InGaN, or SiC
450	Blue	3.8	GaN, InGaN, or SiC
470	Blue	3.8	GaN, InGaN, or SiC
490	Blue-Green	3.6	GaN, InGaN, or SiC
505	Blue-Green	3.6	GaN, InGaN, or SiC
525	Green	3.6	GaN, InGaN, or SiC
555	Green	2.2	GaP
565	Green-Yellow	2.2	GaP
570	Yellow-Green	2.2	GaP
585	Yellow	2.2	InGaAlP or GaP
590	Yellow	2.2	InGaAlP or GaP
592	Amber-Yellow	2.2	InGaAlP or GaP
600	Yellow	2.2	InGaAlP or GaP
612	Orange	2.0	InGaAlP or GaP
625	Red-Orange	2.0	InGaAlP or GaP
630	Red	2.0	InGaAlP or GaP
645	Red	2.0	InGaAlP or GaP
660	Red	1.9	AlGaAs
670	Infrared	1.8	AlGaAs
680	Infrared	1.8	AlGaAs
700	Infrared	1.8	AlGaAs
In = Indium	Ga = Gallium	Al = Aluminum	As = Arsenic
P = Phosphide	Si = Silicon	C = Carbide	N = Nitride

■ TABLE 1. Typical LED Construction.

■ FIGURE 1



Light Emitting Diode

ALL ABOUT LEDS

Q Can you refer me to a source on how LEDs are produced, the colors, and practical aspects of how they can be incorporated in new or existing circuits — including LED types, requirements, and precautions?

— Paul

A An LED is a specialized diode — one that has a conduction band that's much higher than a silicon or Schottky rectifier diode. When a forward diode goes into conduction, the electrons are excited to a higher energy level. When the electron returns to its former energy level, it emits a

photon. In an ordinary diode, the energy gap is small and most of the photon energy is emitted as infrared radiation — where it's dissipated as heat.

LEDs are specially constructed (Figure 1) to release a large number of photons, from infrared to ultraviolet. The color of the light is dependent on the energy level of the photon — which is directly related to the band gap. The more energy it takes to start conduction through the diode junction, the higher the energy of the photon and the shorter the wavelength. (Longer wavelengths, typically 700 nm and longer, emit infrared light; shorter wavelengths of 400 nm and shorter emit ultraviolet light.) The band gap (and resulting wavelength) is determined by the semiconductor material used to fabricate the diode junction (Table 1).

Because LEDs are diodes, they are polarity sensitive, as shown in Figure 2. In the forward direction they conduct, in the reverse direction they block current flow. The amount of current going through the LED determines its brightness. More current, the brighter the LED. The current has to be limited by a resistor, otherwise the LED overheats and literally melts. LEDs are typically biased with 20 mA of forward current, which makes the limiting resistance equal to R = (Vsource - Vf) / LEDcurrent, where Vsource is the battery voltage and Vf is the forward voltage of the LED (Table 1). For further information on LEDs, check out The LED Light website at **www.theledlight.com/technical.html**

AUDIO REPEATER

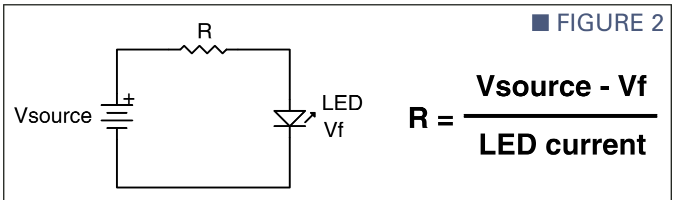
Q I tinker around with smaller radios and televisions and place them into other objects. I have noticed that if I take something like a small jogging radio that only has a headphone jack and try to connect a speaker somewhere to the PC board, it never produces sound. Is there a place on there that I can connect the speaker to or maybe an adapter somewhere to connect to the PC board?

— James

A There could be several reasons why connecting to the PC board won't work. But is wiring to the board itself a priority? I would use the earphone jack to extract the audio from your relocated gizmo. Specifically, find a cheap earphone with the same connector and cut off the earplugs, keeping the plug and its exiting wires (which may be shielded). That will get you to the audio output, but it may still not drive your speaker. Why? Because most headphone devices output less than 100 mW of power into a 16-ohm load. Certainly not enough to power a four-ohm speaker.

What you need is a power amp, like the one in Figure 3. This circuit will pump out one watt from your wimpy earphone jack or electret mike. Better yet, you don't even have to scrounge the parts yourself. Kits-R-Us makes a complete kit (Kit 17) that includes an etched and drilled printed circuit board. It is available from Alltronics (408-778-3868; **www.alltronics.com**) and others for as low as $6.95. My design combines the right and left channels; if you want stereo sound, you need two amps.

■ FIGURE 2



LED Current Limiter

IR REPEATER

Q I have been trying to build an IR repeater so I can hide my electronic equipment in a cabinet, but have had no luck. My first idea was just to use an IR receiver diode and transmit it back using a voltage follower. That did not work! So I went to the Internet and found a circuit using a 555, which also didn't work. I am all out of ideas and I was hoping maybe you had a schematic or know where to find one.

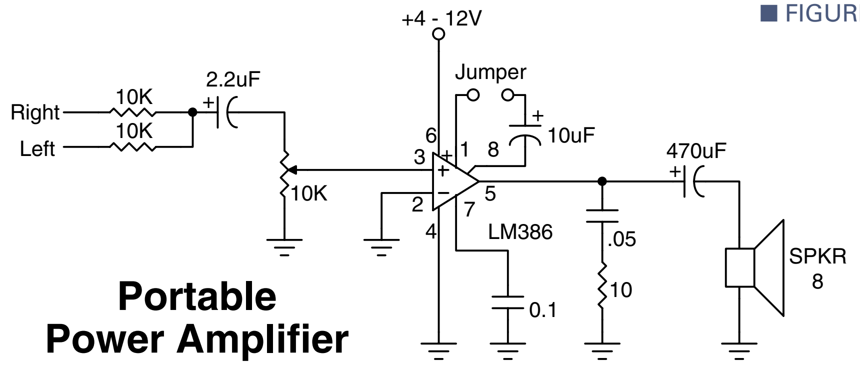
— Alex Curiel

A Check out the IR repeater circuits in the April 2003 issue. That column is also full of other wireless solutions and a tutorial on crystal oscillators. In case you missed that issue, Figure 4 shows a copy of one of the repeaters. The beauty of this circuit is that the carrier frequency is adjustable via the CAL potentiometer, which allows you to use it with a wide range of IR senders. The visible LED (on pin 1 of the receiver module) can be used to tune the oscillator. Flip the RUN/CAL switch to the CAL position, position the IR LED in front of the IR receiver, and adjust the CAL pot until the visible LED lights brightly.

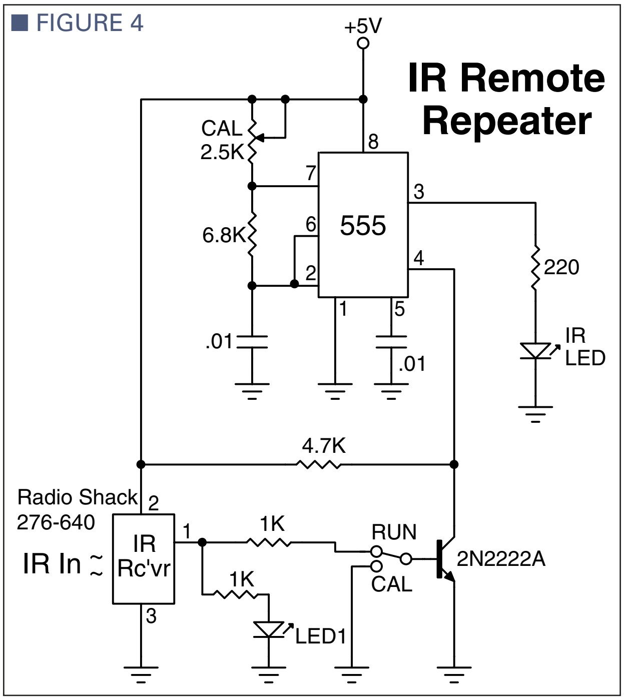
PULL-UP OR PULL-DOWN

Q I picked up a new 68HC705J1A development kit on the cheap. I'm just getting started and would like to do some programming and build a few projects. About the I/O ports on the 68HC705J1A, should they be pulled up or pulled down? And if so, how do you know which it is? How do you know

■ FIGURE 3



Portable Power Amplifier



■ FIGURE 4

what value the resistors are?

— Mack

A Very good question, and one that needs more than a yes/no style answer. Your specific microcontroller has programmable pull-downs. That is, you can ground these pins via software. Other controllers — like the PIC — support software programmable pull-up resistors. The problem is that these are weak resistors — they have no power handling capabilities.

External pull-up resistors are normally used for two purposes:

1) If you leave an input floating, it may oscillate or come to some indeterminate state which can cause high-current thermal runaway in CMOS. It's generally wiser to pull the input up rather than ground it. (You're going to get a lot of opinions on this. Ground level normally has less noise than Vcc, but can dissipate more power.)

2) A hard pull-up makes for faster switching time. Why? Because all devices have a capacitive element — a "built-in" capacitor that has to be charged and discharged when switching from on to off. By putting an external pull-up resistor on an input or output port, this latent capacitor will charge or discharge faster. Oh, before I forget, I generally use a 10K resistor.

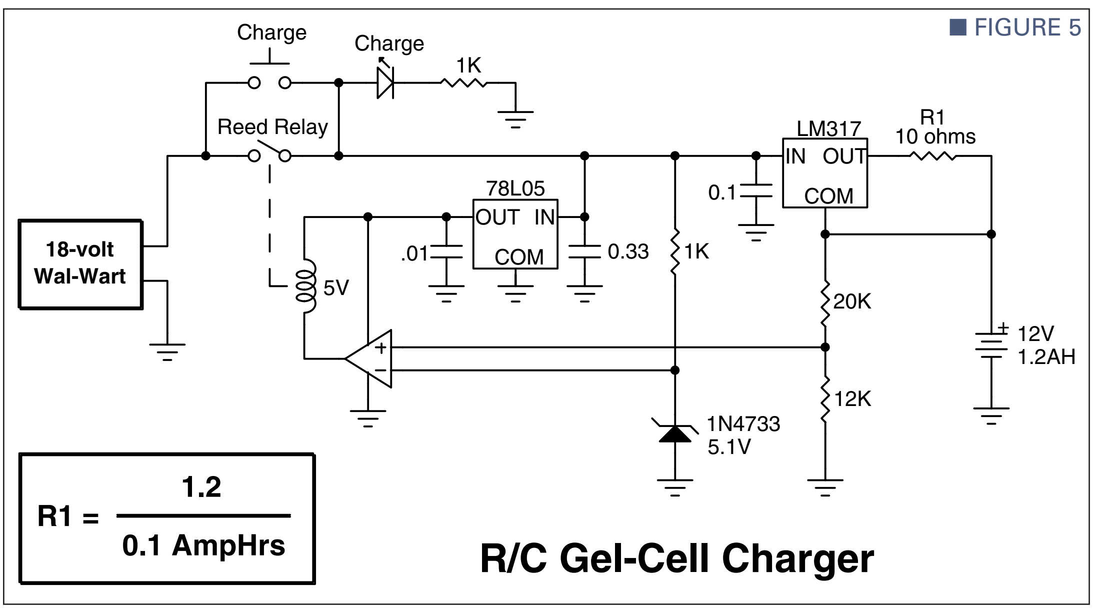
HOW DO I CHARGE IT?

Q I recently purchased a sealed rechargeable 12-volt 1.2 Ah battery to replace the dry type in an R/C transmitter. The problem is that the battery's data sheet does not give the recommended charging rate, but does suggest using a "constant voltage-current limited" charger. Could you please shed some light on this charging method, and perhaps provide a circuit to safely charge this battery?

— D.E. Baum
Cottonwood Heights, UT

A Because they are sealed and more fragile than flooded (wet) lead-acid batteries, gel-cells should be lightly charged by the 1/10th method — as in 1/10th of the amp-hour (Ah) rating is used to charge the battery for up to 12 hours, after which the battery is disconnected from the charger. This is especially true for gel-cells under 6 Ah. For your battery, that equals 120 mA of charging current until the battery reaches 13.6 volts. The following circuit, Figure 5, is semi-automatic in that respect.

The charger is nothing more than an LM317 voltage regulator — configured as a constant-current source — controlled by a latching cut-off switch after the battery is fully charged. To start charging the gel-cell, press the Charge push-button and stand back. This will engage the reed relay, light the Charge LED, and direct charging current into the battery. When the battery voltage reached 13.6 volts, the comparator output goes high, the relay drops out, the charging stops, and the Charging LED turns off. (Notice, there is no number on this op-amp/comparator chip. Whatever you have in your junk box or can find at RadioShack will work, i.e., LM339, LM741, etc.)



■ FIGURE 5

R/C Gel-Cell Charger

SOLAR BATTERY CHARGER

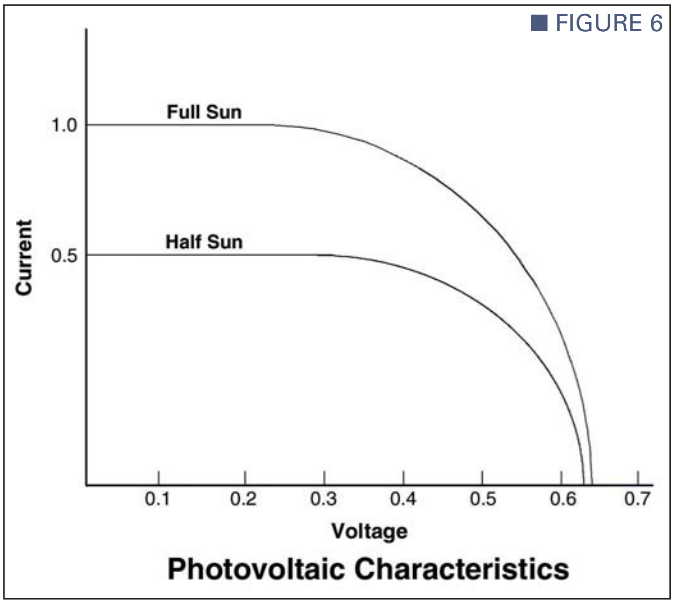
Q I need a circuit that will charge a 3.6 volt Li-Ion cell-phone

battery from an 11-volt solar array (I don't think it has more than one amp of output current). Would it be possible to charge two at once and form a single 7.2 volt battery?

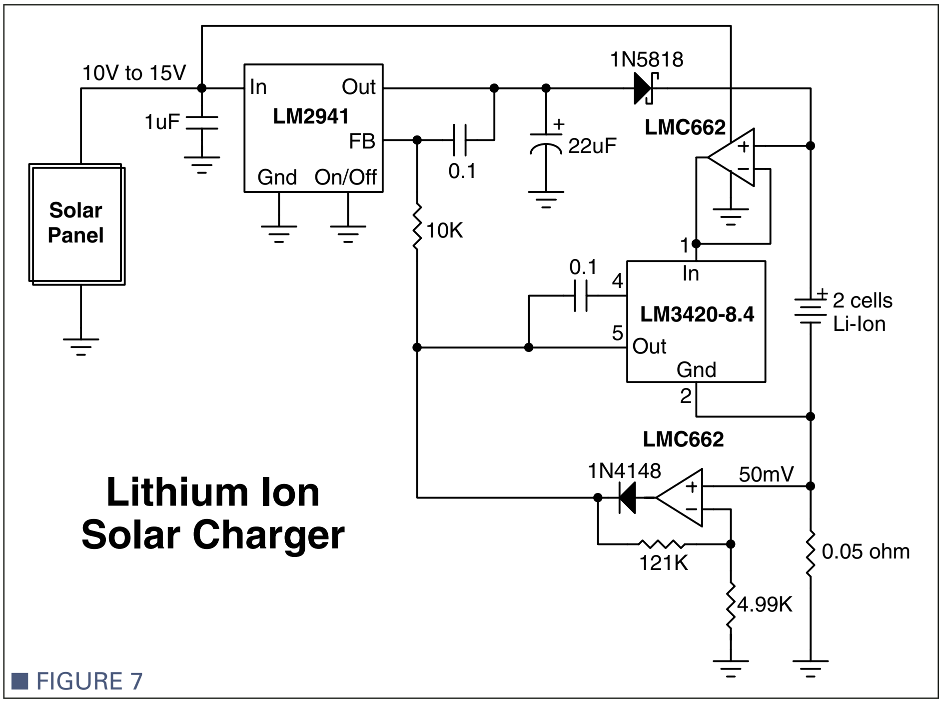
— Daniel

A Your power source requires a charger with high efficiency and a range of input variables — one that includes long periods of no power and varying current. The output current is proportional to the intensity of the light falling on the solar cells, whereas the voltage remains more or less constant (Figure 6). The ideal battery charger for this situation would be a low dropout regulator controlled by a lithium-ion battery charge controller (Figure 7).

With a discharged battery connected to the charger, the circuit operates as a constant current source. When the current reaches 1A, it is sensed by the 0.5-ohm resistor, which produces 50 mV. This 50 mV is amplified by the op-amp to produce 1.27 volts, which is applied to the feedback pin of the LM2941. Once the battery voltage reaches 8.4V, the LM3420 takes over and begins to control the feedback pin of the LM2941. The LM3420 now regulates the voltage across the battery, and the charger becomes a constant-voltage charger. When the sun goes down, the 1N5818 diode becomes reversed biased and effectively disconnects the battery to prevent it from discharging through the electronics.



■ FIGURE 6



■ FIGURE 7

BATTERY EQUALIZER

Q I have an electric wheel chair that uses two 12-volt gel cells in series for 24 volts DC. Over the years, I've noticed that after the batteries have been discharged (unevenly), I can no longer get a uniform charge out of the on-board switching charger. One battery will reach a high voltage and the other will be about 0.5 volts lower. I suspect that the internal battery resistance is rearing its ugly head. Why do the batteries fail to balance out? Can they be balanced so they each will have the same capacity? And how?

— F.J.G.

A This often happens when batteries are wired in series and charged from a single voltage source. In extreme conditions, where the battery is discharged very deeply, one of the cells can become reverse charged — but it's more likely to occur in NiCd batteries than in gel cells. Uneven battery cells lead to increased sulfating and reduced battery life.

The solution to unequal battery voltages is called equalization. This is a charge that is about 10% higher than normal full charge voltage — 14.4 volts for a 12-volt battery — and is applied for about two to 16 hours. Flooded batteries should be placed on an equalizing charge every 10 to 40 days. Gel cells should be equalized only two to four times a year — at most. The equalization process works best if you separate the individual batteries and equalize them separately.

FOR WHOM THE RUST TOLLS

Q I have two questions about lead-acid batteries.

1) We know that the battery life is determined by the number of charge/discharge cycles (200-500 cycles). What exactly happens inside the battery after each charge/discharge cycle that causes the remaining number of cycles to be reduced by one count?

MAILBAG

Dear TJ,

The December issue (page 13) has the 7805 regulator backwards.

— John

Response: *Yes it does! For those readers trying to duplicate the "Motor Speed Controller" circuit, reverse the IN and OUT pins. I have also had requests for the source of the IPS031 Smart FET. It is available from Digi-Key, Allied, and Newark.* — *TJ*

Dear TJ,

The Dec. 2005 column has a question about a telephone ringer. The easiest way to get one is to order it from Jameco Electronics. It is the "Black Magic" ringer, LNU-BMR12V, Jameco stock number 145816. It requires 12 volts input and outputs 86 VAC at 20 Hz.

— Bill Stiles

2) Battery manufacturers tell us that the maximum charging voltage should not be exceeded 2.43 volts per cell. What happens inside the battery if this limit is exceeded?

— M.J.

A To begin with, there isn't really a number of charge/recharge cycles assigned to a battery. It can range between 200 to 1,000 — depending on how the battery is used. First, it's important to understand the chemistry of the lead-acid cell. To make a long story short, suffice it to say that the lead-acid cell is a secondary battery. That is, it doesn't generate electricity — like an alkaline primary cell — but stores a charge using reversal chemistry. In the case of the lead-acid cell, the chemistry is "lead rust" — lead oxide to be exact.

In laymen's terms, you move the lead rust from one lead plate to the other using sulfuric acid as the carrier. Between charge and discharge, this "rust" goes back and forth. Ever see what happens to a piece of iron or steel as it goes through rust cycles? Each time you "brush" it to get down to the bare metal, you lose material. Same with the plates in the battery. It's called shedding. Each time the cycle is reversed, some rust is shed. The deeper the discharge, the more rust involved. So as to how long a battery will last, it depends on how deeply it's discharged and how thick the lead plates are to begin with. The more lead you start with, the more there is to lose before there is no longer a plate.

As to your second question, exceeding the charging voltage per cell affects the sulfuric acid electrolyte more than the plates. As the charging current continues over time, it raises the temperature of the aqueous solution to the point where it actually boils. Now you know what happens to boiling water — it evaporates. Since the battery needs the electrolyte to operate ... well, figure it out for yourself. In rare cases, high overcharging temperatures may warp the plates. When this happens, the plates can puncture the separator that goes between the positive and negative plates (they are interlaced) and short out — rendering the battery useless.

BATTERY BASICS

Q You had a question about a 6V, 9.5 Ah gel-cell battery in the Jan. 2005 issue and explained an interesting method to "blow" the sulfate off the plates of the battery by using high current pulses. My question: If the battery is dead and cannot accept charging current from the regular chargers, how can this method be used? Another question please, can this method be used to bring life back into a dead car battery?

— Zacky

A First, read the answer to the question above, "For Whom The Rust Tolls." What I didn't say in that answer is that between charges and disuse, the plates of the battery absorb sulfate ions from the sulfuric acid electrolyte. Basically, the lead plates get sulfated in three stages. The first stage is surface sulfates that are quickly dissolved

with frequent charging. If the battery sits for a while unused, the sulfates dig deeper into the plate. This renders that part of the plate useless because it can't conduct current as readily as a clean plate. Fortunately, this layer can be recovered by keeping the battery on a trickle charge. If left too long, though, the sulfate will eventually go into what's called level 3 penetration, where the plate is worthless as a conductor (sulfur is an insulator) and normally not reversible. So, you tell me. Has this battery been sitting for so long that the sulfate has progressed to level 3 — stage 4 cancer? If it's at a level 1, put the battery on a trickle charge. If it's at level 2, put it on a trickle charge for longer. If it's at level 3, try my pulsing charger and hope for the best.

What are the chances of bringing a dead car battery back to life? Zip to zilch. Car batteries have calcium-lead plates, which provide a large amount of current for short periods, but have little endurance. Think of the car battery as a Cheetah — a very fast cat with a huge burst of speed, but can't complete a marathon. The plates are large in area, but very thin and very subject to shedding when deeply discharged. In fact, a car battery should never be discharged below 90% of total capacity. Doing so quickly depletes the lead paste in the plates.

Did I mention that deep discharge doesn't have to come from use? It can also come from just having the battery sit on a shelf (or under the hood unused). A battery has impurities in the electrolyte that causes current to flow within the battery proper between the positive and negative plates. A rule of thumb, this amounts to 10% per month. (But don't quote me on that. It depends on the battery itself.) So after 10 months, the battery could spend all its energy internally and have sulfated to the point where it may never accept a charge simply because there's no conductive surface left. You can try pulsing the battery, but don't hold your breath. **NV**

COOL WEBSITES

Sudoku is a puzzle craze that has recently swept the globe. Enter this speed challenge and see if you are the best at Sudoku.

www.sudokufun.com/

Free Sudoku puzzles from around the world; play on-line, download, or print.

www.sudoku-puzzles.net

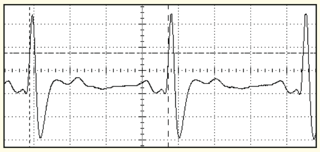
Here is a JavaScript program that allows users to enter the starting position of a Sudoku puzzle and then sit back and watch as the solution appears on screen.

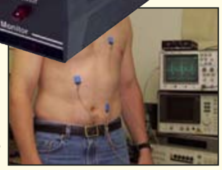
http://nl.internet.com/ct.html?rtr=on&s=1,1z7m,1,dgik,hkua,3qmh,cu1s

Valentine's Day Goodies!

Electrocardiogram ECG Heart Monitor

- ✔ Visible and audible display of your heart rhythm!
- ✔ Bright LED "Beat" indicator for easy viewing!
- ✔ Re-usable hospital grade sensors included!
- ✔ Monitor output for professional scope display
- ✔ Simple and safe 9V battery operation





February is Valentine's Day month, and what a great time to think of your heart! Not how many times it's been broken, not how many times it's fallen head over tails in love, but how it actually works...and how it's doing these days!

Use the ECG1C to astound your physician with your knowledge of ECG/EKG systems. Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it. The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The documentation with ECG1C covers everything from the circuit description of the kit to the circuit description of the heart! Multiple "beat" indicators include a bright front panel LED that flashes with the actions of the heart along with an adjustable level audio speaker output that supports both mono and stereo hook-ups. In addition a monitor output is provided to connect to any standard oscilloscope to view the traditional style ECG/EKG waveforms just like you see on ER... or in the ER! See the display above? That's one of engineer's hearts after an engineering meeting!

The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading and display every time! 10 hospital grade re-usable probe patches are included together with the matching custom case set shown. Additional patches are available in 10-packs. Operates on a standard 9VDC battery (not included) for safe and simple operation. Note, while the ECG1C professionally monitors and displays your heart rhythms and functions, it is intended for hobbyist usage only. If you experience any cardiac symptoms, seek proper medical help immediately! *(Like I did after I got the ad deadline date for February from Robin!)*

ECG1C	**Electrocardiogram Heart Monitor Kit With Case & Patches**	**$44.95**
ECG1WT	**Electrocardiogram Heart Monitor, Factory Assembled & Tested**	**$89.95**
ECGP10	**Electrocardiogram Re-Usable Probe Patches, 10-Pack**	**$7.95**

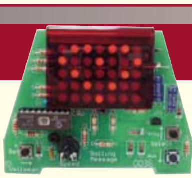
Personal Animated Badge

- ✔ Create your own graphic!
- ✔ 8 animations, 25 frames storage!
- ✔ Adjustable speed and brightness

Show that special person how you really feel! Create your own graphic animations and text that will be displayed in full motion on this personal "badge"! Up to 8 animations of 25 frames can be stored and selected for display. Adjustable speed and two brightness levels give your messages a custom look. Animates are drawn via the RS232 input with provided software. Includes RS232 cable, CD with edit software and samples. Runs on one 3VDC CR2032 battery (included) for more than 50 hours. Measures 3.1" x 1.9". Can be handheld worn as a necklace. Factory assembled & tested, ready to go!

VM112 Personal Animated Badge $49.95

Rolling Message Display



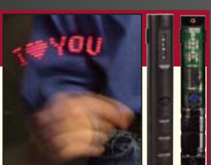
- ✔ Scrolling motion display!
- ✔ 35 bright LED display!
- ✔ 16 character message!
- ✔ Adjustable speed

Create your own scrolling or rolling message with this high visibility LED display! Contains 35 brilliant LEDs to provide each character of your custom message up to 16 characters. From special characters like the heart shown, to standard text, your message will grab attention like no other display can!

Built-in message editor is simple to use. Press "set" to change a character, then use the "up/down" key to select the character and end with the "<" key. Includes a standby/run mode to restart the display. Runs on 9-12VDC and uses a type 6LR61/6F22 backup battery if desired. Entire display board measures 1.8" x 3.5" x 2.6".

MK124 Rolling Message Display Kit $14.95

LED Magic Message Wand



- ✔ Message floats in air!
- ✔ Fun at concerts & events!
- ✔ High visibility red LEDs
- ✔ Pre-programmed or custom messages

Use the "Magic Wand" to display your true feelings! Simply shake it back and forth and brilliant messages seem to appear in mid-air! Six high intensity LEDs are microprocessor controlled to display messages and graphics that are pre-programmed into the wand.

You can also custom program a message of your choice! From amazing your friends, making a statement at a concert, or simply telling your loved one how you feel, the message wand can't be beat!

Runs on two AAA batteries (not included), and the auto power off circuit gives you long battery life. Measures 6.4" x 1" x .9".

MK155 LED Magic Wand Kit $16.95

LCD Mini Message Board

- ✔ 124 character Eprom!
- ✔ Built-in text editor!
- ✔ Adjustable speed
- ✔ RS232 built-in interface

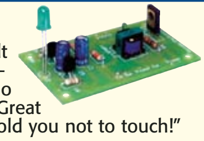
Display your custom message the hi-tech LCD way complete with an attractive tilting enclosure and mount! A 16 character 1 line backlit LCD display shows everyone your custom message! The built-in Eprom message memory handles up to 124 characters. The message scrolls with adjustable speed.

The message can be created with the built-in message editor or via the RS232 PC interface for simple uploading and displaying. Besides personal messages the display is perfect for exhibitions, advertising, retail displays, attention getters, serial display for equipment and much more. Runs on standard 9VDC battery at 100mA. The included case measures 4.5" x 1.7" x 3".

MK158 LCD Mini Message Board Kit $19.95

Mini-Kits... The Building Blocks!

Tickle-Stick



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC

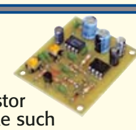
TS4 Tickle Stick Kit $12.95

Super Snoop Amplifier

Super sensitive amplifier that will pick up a pin drop at 15 feet! Full 2 watts output. Makes a great "big ear" microphone. Runs on 6-15 VDC

BN9 Super Snoop Amp Kit $9.95

Dripping Faucet



Produces a very pleasant, but obnoxious, repetitive "plink, plink" sound! Learn how a simple transistor oscillator and a 555 timer can make such a sound! Runs on 4-9 VDC.

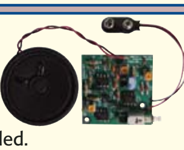
EDF1 Dripping Faucet Kit $9.95

LED Blinky

Our #1 Mini-Kit for 31 years! Alternately flashes two jumbo red LED's. Great for signs, name badges, model railroading, and more. Runs on 3-15 VDC.

BL1 LED Blinky Kit $7.95

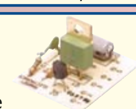
Cricket Sensor



Senses temperature and changes the chirp accordingly. Can actually determine temp by chirps! Runs on 9VDC battery. Speaker included.

ECS1 Cricket Sensor Kit $24.95

Electronic Siren



Produces the upward and downward wail of a police siren. Produces 5W output, and will drive any speaker! Runs on 6-12 VDC.

SM3 Electronic Siren Kit $7.95

Universal Timer

Build anything from a time delay to an audio oscillator using the versatile 555 timer chip! Comes with lots of application ideas. Runs on 5-15 VDC.

UT5 Universal Timer Kit $9.95

Voice Switch

Voice activated (VOX) provides a switched output when it hears a sound. Great for a hands free PTT switch, or to turn on a recorder or light! Runs on 6-12 VDC and drives a 100 mA load.

VS1 Voice Switch Kit $9.95

Tone Encoder/Decoder

Encodes OR decodes any tone 40 Hz to 5KHz! Add a small cap and it will go as low as 10 Hz! Tunable with a precision 20 turn pot. Runs on 5-12 VDC and will drive any load up to100 mA.

TD1 Encoder/Decoder Kit $9.95

RF Preamplifier

Super broadband preamp from 100 KHz to 1000 MHz! Gain is greater than 20dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 RF Preamp Kit $19.95

Touch Switch

Touch on, touch off, or momentary touch hold, your choice! Uses CMOS technology. Runs on 6-12 VDC and drives any load up to 100 mA.

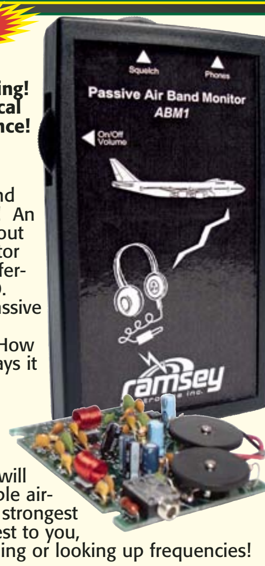
TS1 Touch Switch Kit $9.95

What's New For 2006!

The Newest And Neatest Goodies

Digital FM Stereo Transmitters

New For 2006



- ✔ **Monitors the entire aircraft band without tuning!**
- ✔ **Passive design, can be used on aircraft, no local oscillator, generates and creates no interference!**
- ✔ **Great for air shows**
- ✔ **Patented circuit and design!**

For decades we have been known for our novel and creative product designs. Well, check this one out! An aircraft receiver that receives all nearby traffic without any tuning. It gets better... there is no local oscillator so it doesn't produce, and can't produce, any interference associated with all other receivers with an LO. That means you can use it onboard aircraft as a passive device! And what will you hear? The closest and strongest traffic, mainly, the one you're sitting in! How unique is this? We have a patent on it, and that says it all!

This broadband radio monitors transmissions over the entire aircraft band of 118-136 MHz. The way it works is simple. Strongest man wins! The strongest signal within the pass band of the radio will be heard. And unlike the FM capture effect, multiple aircraft signals will be heard simultaneously with the strongest one the loudest! And that means the aircraft closest to you, and the towers closest to you! All without any tuning or looking up frequencies! So, where would this come in handy?

1. ***At an air show! Just imagine listening to all the traffic as it happens***
2. ***Onboard aircraft to listen to that aircraft and associated control towers***
3. ***Private pilots to monitor ATIS and other field traffic during preflight activities (saves Hobbs time!)***
4. ***Commercial pilots to monitor ATIS and other field traffic as needed at their convenience***
5. ***General aircraft monitoring enthusiasts***

Wait, you can't use a radio receiver onboard aircraft because they contain a local oscillator that could generate interfering signals.

We have you covered on that one. The ABM1 has no local oscillator, it doesn't, can't, and won't generate any RF whatsoever! That's why our patent abstract is titled "Aircraft band radio receiver which does not radiate interfering signals". It doesn't get any plainer than that! Available as a through-hole hobby kit or a factory assembled & tested SMT version.

SPECIFICATIONS

Frequency Range:	118 MHz to 136 MHz
Receiver Type:	Patented Passive Detector
IF Frequencies:	None!
Receiver Sensitivity:	Less than 2 uV for detectable audio
Audio Output:	700mW, 8-24 ohms
Headphone Jack:	3.5mm stereo phone
External Antenna:	Headphone cord coupled
Power Requirement:	9VDC battery
Dimensions:	2.25" x 2.8" PC Board 2.5" x 4.6" x .9" Case
Weight:	4 oz. with battery

ABM1	**Passive Air Band Monitor Kit**	**$89.95**
ABM1WT	**Passive Air Band Monitor, Factory Assembled & Tested**	**$159.95**

Hand Held Wind Speed Anemometer

New For 2006

- ✔ **Displays instantaneous wind speed!**
- ✔ **Stores & records maximum gusts and averages!**
- ✔ **Displays temperature and wind chill in °F or °C !**
- ✔ **Beaufort wind scale bargraph!**

We have all seen them on TV... the professional weather talent (now known as meteorologists!) standing in the middle of the hurricane report holding up their wind meter clocking the fastest wind gusts. Usually that's just before they get blown to the ground along with their producer and camera crew! Well now you can have the same professional wind speed meter on a hobbyist budget! Besides displaying the realtime instantaneous wind speed in your choice of MPH, KM/H, M/S, or Knots, it also stores and records the maximum gust AND average since it was powered up! In addition, realtime wind speed is also displayed on a Beaufort wind scale ranging between 0 and 12. Housed in a rugged, weather resistant case and includes a neck strap for easy carrying. Runs on a single lithium button cell that is included. Factory assembled, tested, and ready to go!

EA3010	**Handheld Wind Speed Anemometer**	**$49.95**

Just Off The Press!

Get the 2006 Ramsey Hobby Catalog! ***104 value packed pages*** of the neatest goodies around with over 150 new items! Order yours today on line or give us a call. Or download the PDF!

High Resolution Air Pressure/Elevation Sensor

New For 2006

- ✔ **Pressure resolution greater than 0.0001kPa!**
- ✔ **128 x 64 pixel graphical display!**
- ✔ **Shows realtime elevation & pressure changes!**
- ✔ **USB computer interface for easy data transfer!**
- ✔ **13,824 samples of FLASH storage available!**
- ✔ **Special pilots menu**
- ✔ **Multiple built-in alarms**

"The Most Advanced And Accurate Ramsey Kit To Date!"

We really did it this time! The UP24 is one of our most advanced kits to date, and an absolute MUST for anyone serious about the environment around us! But the applications only begin there.

The unique design allows unprecedented super high resolution measurements and display of absolute atmospheric air pressure. The UP24 senses ambient air pressure and critically calculates elevation with unheard of precision! Using a highly sensitive sensor and 24-bit A/D converter in a special noise-immune design, less than 1/3" of an inch of elevation resolution is achieved! YES, we said 1/3 of an inch! This high accuracy and resolution opens the door to a host of sophisticated environmental air pressure monitoring applications.

Unlike your normal run-of-the-mill barometer, air pressure is sensed in Pa's or kPa's. What are those you may ask? Pascals or KiloPascals. However, don't be afraid, for your convenience, and to fit any application you may have, it is also displayed in millibars, bars, PSI, atmospheres, millimeters of mercury, inches of mercury, and feet of water! Take your pick! The range of the UP24 is 15kPa to 155kPa.

We've talked about air pressure, now let's talk about elevation! The incredibly precise 24 bit A/D converter in the UP24 looks at the air pressure and converts it to elevation above sea level. In both graph and text, the elevation is displayed to a resolution of 1/3"! Yes, I said 1/3 of an inch! The applications for the super accurate elevation meter are endless. From watching and recording elevations during hiking trips to measuring and recording the wave heights on boats! Let your imagination take over from there!

What if you're in the field and you want to save data captured in your UP24? The built-in FLASH storage provides 13,824 samples of storage. Then you can transfer your data to your PC with a standard USB interface.

While the UP24 is small enough to be kept in your coat pocket it boasts a large 2.78" x 1.53" 128x64 pixel LCD display screen making viewing easy. Display modes include both realtime pressure and elevation graphs as well as pressure and elevation statistics. There are 12 user selectable sample rates from 1/10th of a second all the way up to every 15 minutes.

Needless to say, you cannot put all the specs and screen shots in the limited space of this ad! Visit our website at www.ramseykits.com for full specs and information.

If you're looking for the finest air pressure and elevation sensor, check out the UP24, truly a marvel in the industry! Available in a ready-to-build kit or a factory assembled and tested version. Check our website at www.ramseykits.com for more information!

UP24	**High Resolution Air Pressure/Elevation Sensor Kit**	**$239.95**
UP24WT	**Factory Assembled and Tested UP24**	**$299.95**
AC125	**110VAC Power Adapter/Charger**	**$9.95**

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OPEN COMMUNICATION

THE LATEST IN NETWORKING AND WIRELESS TECHNOLOGIES

■ BY LOUIS E. FRENZEL

SHORT-RANGE WIRELESS EXPLOSION

Cypress Semiconductor's Wireless USB chips are a popular but non-standard wireless method for short range applications like computer peripherals, consumer products, and industrial monitoring and control. It is an alternative to ZigBee, Bluetooth, and ISM radios. It operates in the 2.4 GHz band and has a data rate of 62.5 kbps.

WIRELESS EVERYTHING. If it seems like you are hearing and seeing more about wireless devices every day, it's not just your imagination. Over the past few years, there has been a virtual explosion of new wireless devices and services. And I am not just talking about our cell phones which have become our all-purpose, go anywhere, do everything communicating Swiss Army knife equivalents. There really has been a premeditated effort to make anything and everything wireless.

Of course, we have had wireless devices for decades. Our TV, VCR/DVD, stereo remote controls are the main example. But garage door openers have also been around for years. Cordless phones now account for the majority of home phones sold. More recently, almost every new car has a remote keyless entry feature. Wireless toy cars and remote controlled planes and boats have been around for years, too. But today, wireless is replacing cables and showing up in lots of unexpected places. Thanks to a bundle of new wireless standards and cheap radio chipsets, it is possible to incorporate a wireless feature into almost anything.

Wireless is clearly addictive as it makes things more convenient. No one wants to fuss with a cable. Besides, we appreciate the freedom of mobility. Wireless liberates us from our tethered past.

Here is an overview to familiarize you with the current hot wireless technologies.

BLUETOOTH

Bluetooth was originally developed by Ericsson — the Swedish cell phone company — as a cable replacement between a headset and a cell phone. When I first heard of this I asked how much of a problem could a short, three-foot cable between a cell phone and the headset be? Does it really make sense to replace a 25 cent cable with a complicated digital microwave two-way radio? The answer turned out to be a big yes. Now nearly 50% of all cell phones contain a Bluetooth transceiver that communicates with a companion headset. It is a common sight these days to see a person talking on a wireless headset. They even make a version for hands-free operation of a cell phone in a car.

When you put an electronic part in a cell phone, you generate horrendous volume. Over 800 million cell phones were sold last year and if almost half of them contain a Bluetooth chip, that's big volume. Over 500 million Bluetooth chips were sold to date and the ship rate has now increased to nearly 10 million a week. Most of these go into cell phones, of course, but there are many other uses, as well.

When a chip achieves that volume, it means that the price drops to a very low level. Today, a Bluetooth chip sells for less than $5. That makes it attractive for other applications. Other common uses are wireless links between a laptop and a cell phone for Internet access. Bluetooth chips also show up in wireless computer interfaces like keyboards, mice, and printers. No need to buy, string, or worry about a cable.

Bluetooth is a radio standard developed and blessed by the Bluetooth Special Interest Group (SIG). They promote the standard and develop new applications called Profiles. The SIG also conducts testing and certification to ensure that all Bluetooth products interoperate with one another. This ensures that the Bluetooth product from one manufacturer talks to that of any other manufacturer.

Bluetooth operates in the 2.4 GHz unlicensed Part 15 FCC band. It uses frequency hopping spread spectrum with FSK modulation. It is a digital radio with a maximum data rate of 1 Mb/s. A new version 2.0 of the standard is called Enhanced Data Rate (EDR) and transmits data at up to 3 Mb/s. The transmission range is about 10 meters max, depending upon the environment. A higher power version can also be used to achieve a range up to 100 meters with clear line-of-sight between antennas.

One of the key features of Bluetooth is its ability to automatically link up with other nearby Bluetooth devices to form what is called a piconet. One Bluetooth transceiver acts as a

central controller for up to seven other devices who can now exchange data.

Forthcoming versions of Bluetooth may also use a form of ultra wideband (UWB). More about that later.

WI-FI

Wi-Fi means wireless fidelity. It is the trade name of a wireless local area networking (WLAN) technology that has been standardized by the IEEE as 802.11. There are several versions with different frequency bands and data rates. The 802.11b version is the oldest and most common. It operates using direct sequence spread spectrum in the 2.4 GHz unlicensed band, as well with a data rate up to 11 Mb/s at a range up to 100 meters.

The 802.11g version is the most recent. It is backwards compatible with 802.11b. It too operates in the 2.4 GHz band but the data rate is up to 54 Mb/s. This version uses orthogonal frequency division multiplexing (OFDM). Another 54 Mb/s version using OFDM is 802.11a. This version operates in the 5 GHz unlicensed band. There is far less interference up there than in the 2.4 GHz band but the range is shorter, only about 30 to 50 meters.

A newer version is under development. Called 802.11n, it promises data rates from 100 to 600 Mb/s up to 100 meters. It too uses OFDM but also a new technology called multiple input multiple output (MIMO) with two to four antennas and transceivers that operate in parallel. It won't be officially available until late this year or 2007. Some standard "pre-n" versions are available now, but most will wait on the formal standard that will ensure interoperabilty.

Wi-Fi is used in companies to form wireless extensions to their wired Ethernet networks. A wireless access point is set up to talk to PCs and laptops containing a Wi-Fi transceiver interface. No other Ethernet wiring is needed making the process of moving a PC fast and easy. It also allows you to take your laptop into the conference room, cafeteria, or someone else's office and still maintain a link.

Wi-Fi is also the most popular form of wireless home network. With no wiring to worry about, home owners can set up a simple network so that multiple computers can share a fast cable TV or DSL broadband connection, a printer, or other common device. But the most popular application is Internet access and email with a laptop through hot spots — those popular public access points in hotels, airports, coffee shops, and elsewhere. Some cities — notably Philadelphia — are setting up total wireless coverage around the town so that anyone can access the Internet from any place.

Wi-Fi has been around a few years now and is a highly developed technology. It is also used to form mesh networks to provide broadband access to areas where no cable TV or DSL broadband connections are available. And it is beginning to show up in consumer devices like digital cameras and TV sets.

ZIGBEE

ZigBee is a short-range wireless technology designed for monitoring and control operations in commercial buildings, home automation systems, and industrial manufacturing or process control settings. It is an IEEE standard 802.15.4 and a supplementary standard developed by the ZigBee Alliance which also does product testing and certification for interoperability.

There are several versions, but the most widespread is one that operates in the 2.4 GHz unlicensed band. It has a maximum data rate of 250 kbps using offset QPSK modulation. A 868 MHz version at 20 kbps is available for European use and a 915 MHz version at 40 kbps for US and other areas. While the data rate is slow, it is more than sufficient for basic monitor and control operations. The transmission range is short — usually less than 10 meters — but with appropriate antennas, the range can be extended to several hundred meters.

The most common application is remote sensor readings. It can transmit digitized sensor info from temperature, pressure, flow, light, and other sensors to a central monitoring point. It can also send control signals to devices to be operated such as turning lights, motors, relays, valves, or solenoids off or on. In many cases, a wireless link is actually cheaper than a wired link simply because of the high cost of installing wiring these days.

ZigBee's big claim to fame is the ability to automatically form mesh networks. In a mesh network, each transceiver can send or receive data but also act as a repeater to pick up and retransmit data from another source. With such an arrangement, one transceiver can link up with any nearby transceiver and transmit its information over longer distances by simply routing it through other transceivers closer to the destination. Mesh networks are more reliable because if one transceiver fails, the message can still get through the network via an alternative path.

ZigBee is still new but look for first products sometime this year. They will show up in commercial and industrial applications such as lighting, HVAC monitoring and control, automatic meter reading, and security systems. You will see units available for home use later this year and early next year.

ULTRA WIDEBAND (UWB)

UWB is the technology that spreads the signal over a very wide bandwidth at very low power. It was originally developed for secure military communications and radar. But it is now used for high speed data transmissions. Original versions used very short pulses representing the data to create a radio signal with a huge bandwidth usually over 500 MHz wide. Obviously, lots of spectrum space is needed. In the US, the FCC has allocated 3.1 to 10.6 GHz for UWB.

Efforts to create an IEEE standard have failed, but one version of UWB has emerged as the winner in the standards battle. This version uses OFDM. It transmits over 128 bands inside one of three blocks that are each 528 MHz wide. With such an arrangement, data rates from 100 Mbps to 1 Gbps are possible. The range is very short, however. Maximum range is very short, typically only 10 meters and that is at the lower 100 Mbps data rate. At a rate of 500 Mbps to 1 Gbps, the range is only a couple meters. The companies belonging to the Wimedia Alliance have agreed on this as a standard and

will begin a testing and certification program like Wi-Fi and ZigBee.

How is this used? The plan is to use it to transmit video over short distances such as to wall-mounted TV screens and between TV sets and DVD players and other video gear. Video requires very high speeds and UWB can do it. Another application is a wireless USB port for PCs and laptops. The USB serial interface is the most widely used today with data rates to 480 Mbps. A wireless version will replace cables everywhere.

UWB is still new and just now emerging from development. But we should see some real consumer products using it this year. The Bluetooth SIG is expected to adopt UWB for their next higher speed version in the coming years, further increasing its usage.

RADIO FREQUENCY IDENTIFICATION (RFID)

RFID is the radio equivalent of a bar code. A tiny radio transceiver and a memory containing an ID number and other information is built into a tiny chip with an antenna to create what is called an RFID tag. The tag can be pasted on almost any item. When the tag is brought near an interrogator or reader unit, the tag transmits its information to the reader. A neat feature is that the tag has no battery or other power supply. Instead, the tag draws its power from the radio signal radiated by the reader. That RF is rectified and filtered into DC to power the tag. The tag then transmits its data back to the reader. The power is very low so read distances are only a few inches to a couple of feet max. Active tags with a battery give more power and can be read over a longer distance.

The original tags operated on 125 kHz, but the range was very short. Longer range units use the license-free frequency of 13.56 MHz. Newer, second-generation tags operate in the 800-900 MHz UHF range and have a range of many feet.

RFID tags are designed for a wide range of uses. Inventory control in a warehouse, asset tracking, as well as shipping and handling. RFID is also used in automatic toll collection and payment for gasoline at the pump and automated entry to parking areas. It is used in employee ID cards that are read to allow entry to the workplace. RFID has already been adopted by the military and many large retailers like Walmart. Look for others to use it as the volume increases and tag prices drop.

INFRARED

Infrared (IR) wireless uses infrared light to transmit data. Most TV and other remote controls use IR. Yet, it can be used for other data over short ranges. It has been used in printers, PDAs, laptops, and a few other devices. Data rates of 4 and 16 Mbps are available. The biggest limitation is the range which only extends up to several feet and there has to be a clear line-of-sight path because IR is light and can be blocked unlike radio waves. IR wireless is just a niche, but for some applications, it is a good fit. Besides, it is probably the cheapest wireless you can get.

NEAR FIELD COMMUNICATIONS (NFC)

This is a relatively new wireless technology pioneered by Sony and Philips. The term near-field refers to the radio waves directly around the antenna which is mainly a magnetic field. The far field is made up of both the electric and magnetic fields. NFC is designed for very short range operation, typically less than 20 centimeters or roughly about eight inches. That is short range. NFC is similar to RFID in that it can be a passive communication where a device communicates with a reader or base station and derives its operating power from the transmitter. An active mode assumes that the device is also self powered, giving the device a longer transmission range. Some of the items to be NFC-enabled are cell phones, PDAs, and digital cameras. A smart card can also use it.

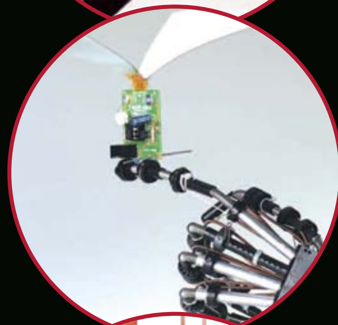
NFC uses the worldwide unlicensed frequency of 13.56 MHz. The devices transmit identification information such as name and address and things like a credit card number. The data rate is 106 kbps, 212 kbps, or 424 kbps, depending on range and application.

NFC has several potential applications. First, it can be installed in a cell phone or PDA and used to make payments, buy tickets, or gain entry to certain places. In this way, it acts almost like an RFID tag. NFC is also targeted at uses such as establishing other wireless communications links such as connections between two Bluetooth or Wi-Fi enabled devices that do not initially talk to one another. By simply bringing the two devices close together, they exchange protocols and other connection data to establish a network, then the devices launch into communications by way of Bluetooth or Wi-Fi. Look for NFC this year and expanding next year.

ISM BAND RADIO

Let's not forget those simple radios using the Industrial-Scientific-Medical (ISM) bands from about 300 to 500 MHz. Typical operating frequencies are 315 and 433 MHz. This is where your garage door opener and remote keyless entry devices work. Another common application is the wireless temperature sensor and wireless tire pressure measuring systems in some cars. When very simple data must be transmitted and no complex multilayer protocol is necessary, this is the wireless to use. The chips are cheap, plentiful, and very easy to use.

Is wireless everywhere? Not yet, but we are well on the way. And an amazing fact is that multiple radios are showing up in some devices, especially cell phones. Besides the cell phone transceiver, some handsets also contain the Bluetooth transceiver as described earlier. Some of the more exotic cell phones also contain a Wi-Fi transceiver that can be used to make Voice over Internet Protocol (VoIP) calls through any access point or hot spot. Some cell phone manufacturers are even thinking of putting ZigBee in a cell phone for remote control of home devices. And certainly look for NFC in phones. A cell phone could end up with five or six radios inside. The challenge will be to keep them from interfering with one another. Is that too much of a good thing or what? **NV**

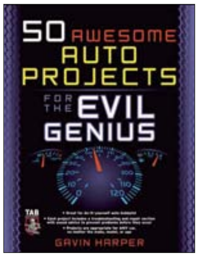


Selected Titles for the Electronics Hobbyist and Technician

The Nuts & Volts Hobbyist BOOKSTORE

AUTOMOTIVE

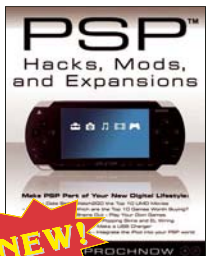
50 Awesome Auto Projects for the Evil Genius
by Gavin D J Harper



The Evil Genius format is the perfect "vehicle" for 50 incredible automotive projects that are compatible with any car, no matter what make, model, or year. Focusing on low-cost, easily obtained components, *50 Awesome Auto Projects for the Evil Genius* lists the items needed to complete each project along with a troubleshooting and repair section. **$24.95**

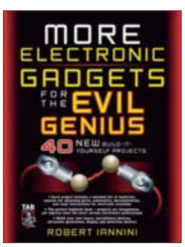
ELECTRONICS

PSP Hacks, Mods, and Expansions
by Dave Prochnow



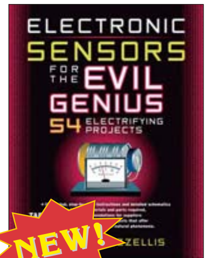
Packed with the mother lode of geek tweaks, tricks, and upgrades, award-winning how-to writer Dave Prochow's *PSP™ Hacks, Mods, and Expansions* gives you everything you need to morph your Sony PlayStation® Portable into the hottest handheld on the planet. You can't find more PSP fun, finesse, and future-features anywhere! To make the whole trip more gratifying, Dave smoothes the way for those who merely aspire to geekdom. Within this book's covers, you'll find complete, goof-proof, illustrated, insider's guidance. **$24.95**

MORE Electronic Gadgets for the Evil Genius
by Robert E. Iannini



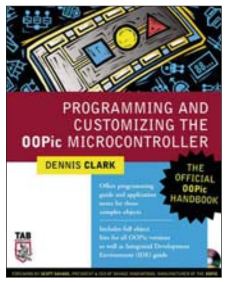
This much anticipated follow-up to the wildly popular cultclassic *Electronic Gadgets for the Evil Genius* gives basement experimenters 40 all-new projects to tinker with. Following the tried-and-true Evil Genius Series format, each project includes a detailed list of materials, sources for parts, schematics, documentation, and lots of clear, well-illustrated instructions for easy assembly. Readers will also get a quick briefing on mathematical theory and a simple explanation of operation along with enjoyable descriptions of key electronics topics. **$24.95**

Electronic Sensors for the Evil Genius — 54 Electrifying Projects
by Thomas Petruzzellis



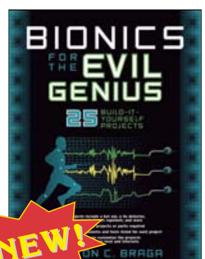
Nature meets the Evil Genius via 54 fun, safe, and inexpensive projects that allow you to explore the fascinating and often mysterious world of natural phenomena using your own home-built sensors. Each project includes a list of materials, sources for parts, schematics, and lots of clear, well-illustrated instructions. Projects include rain detector, air pressure sensor, cloud chamber, lightning detector, electronic gas sniffer, seismograph, radiation detector, and much more. **$24.95**

Programming and Customizing the OOPic Microcontroller
by Dennis Clark



If you're a robotics professional or hobbyist, here's the one book you'll need to keep your work on the leading edge — *Programming and Customizing the OOPic Microcontroller*. This is the official OOPic Handbook, fully endorsed by Savage Innovations, the world's only manufacturer of OOPic microcontrollers. As the first book of its kind, this volume is destined to become the standard against which all other OOPic books will be judged. **$39.95**

Bionics for the Evil Genius
by Newton C. Braga



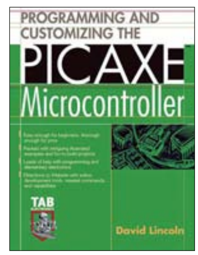
Step into the future — (or the past, if you have a touch of Dr. Frankenstein in your soul) — with these 25 incredibly cool bionic experiments! Demonstrating how life forms can be enhanced, combined, manipulated, and measured with electronic and mechanical components, these inexpensive projects from internationally renowned electronics guru Newton Braga provide hours of fun and learning. Totally safe, *Bionics for the Evil Genius* guides you step by step through 25 complete, intriguing, yet low-cost projects developed especially for this book — including an electric fish, a bat ear, a lie detector, an electronic nerve stimulator, a panic generator, and 20 other exciting bioelectric/mechanical projects! **$24.95**

MICROCONTROLLERS

Introduction to Fiber Optics — Third Edition
by John Crisp

Optic fiber and light — a brilliant combination. What makes the light stay in the fiber? The choice of frequency, propagation of light along the fiber, decibels, losses in optic fibers, dispersion and our attempts to prevent it, real cables, connecting optic fibers — the problems, fusion splicing, mechanical splices, connectors, couplers, light sources and detectors, testing a system, system design — or, will it work?, the transmission of signals, designing an optical system and selecting components, LANs and topology, some final thoughts, glossary, and quiz time answers. **$29.95**

Programming and Customizing the PICAXE Microcontroller
by David Lincoln

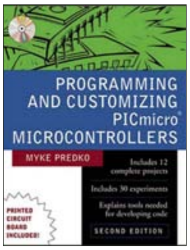


This beginner-friendly guide from IT pro and PICAXE expert, David Lincoln, shows you just what Revolution Education's PICAXE can do — and helps you make it do it! Packed with ready-to-build projects for all the flavors of PICAXE, the guide provides step-by-step help that's ideal for those just starting out with microcontrollers but also takes more experienced programmers where they need to go fast. Using plenty of examples, *Programming and Customizing the PICAXE Microcontroller* clarifies this versatile chip's basics and coaches you through sophisticated applications. **$39.95**

Programming and Customizing the 8051 Microcontroller
by Myke Predko

Myke Predko's *Programming and Customizing the 8051 Microcontroller* puts you in control of the 8051's architecture and instruction set — and even supplies a baker's dozen of ready-to-build example applications, programs, and circuits. Best of all, the included CD-ROM supplies source code for the book's experiments and applications, a demonstration cop of the "UMPS" integrated development environment (IDE), and data sheets for the Dallas Semiconductor and Atmel 8051 compatible devices. **$44.95**

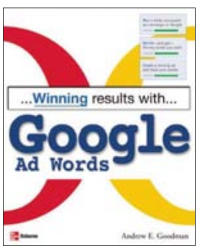
Programming & Customizing PICMicro Microcontrollers
by Myke Predko



This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **$49.95**

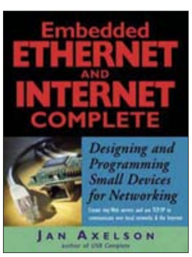
HOME COMPUTING

Winning Results with Google AdWords
by Andrew Goodman



Don't get lost in the digital haystack! With thousands of links for every search, the chances of your products being found online are slimmer than a needle. But there's good news — you can pinpoint your marketing message with help from *Winning Results with Google AdWords*. You'll discover AdWord essentials, how to bid for and win the keywords you want, how to track your results, and much more. Create a profitable ad campaign using online marketing, paid search, targeting, and leveraged branding. **$24.99**

Embedded Ethernet and Internet Complete
by Jan Axelson

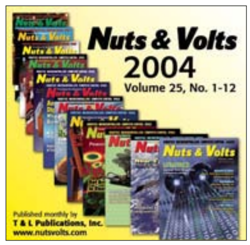


Learn how to design and program devices that host Web pages, send and receive e-mail, and exchange files using FTP. Put your devices on the Internet and monitor and control your devices from across town or around the world. Create private, local networks that enable your devices to share information, send commands, and receive alarms and status reports. Plus: learn about Ethernet controllers, hardware options for networks, networking protocols, and more **$49.95**

SERVO CD-Rom

Starting with the first *SERVO* issue — November 2003 — all of the issues through the 2004 calendar year are now available on a CD that can be searched, printed, and easily stored. This CD includes all of Volume 1, issues 11-12 and Volume 2, issues 1-12, for a total of 14 issues. The CD-Rom is PC and Mac compatible. It requires Adobe Acrobat Reader version 6 or above. Adobe Acrobat Reader version 7 is included on the disc. **$29.95**

Nuts & Volts CD-Rom



Here's some good news for *Nuts & Volts* readers! Starting with the January 2004 issue of *Nuts & Volts*, all of the issues through the 2004 calendar year are now available on a CD that can be searched, printed, and easily stored. This CD includes all of Volume 25, issues 1-12, for a total of 12 issues. The CD-Rom is PC and Mac compatible. It requires Adobe Acrobat Reader version 6 or above. Adobe Acrobat Reader version 7 is included on the disc. **$29.95**

Keep Your Kids Safe on the Internet
by Simon Johnson

Protect your children from dangers that lurk on the Internet. Learn to identify the real threats and formulate an effective protection plan. Choose the best software for your needs and your budget from the book's independent review of firewalls, web filters, anti-virus products, and more. Plus, a companion website hosted by the author includes updated data and information. Get FREE eTrust EZ Antivirus Software for ONE YEAR with purchase of this book — a $29.95 USD value. **$19.99**

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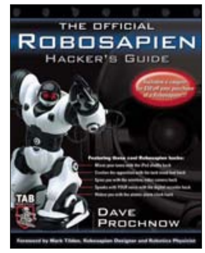
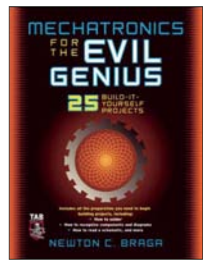
ROBOTICS

The Official Robosapien Hacker's Guide
by Dave Prochnow



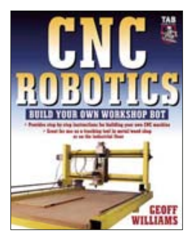
The Robosapien robot was one of the most popular hobbyist gifts of the 2004 holiday season. The brief manual accompanying the robot covered only basic movements and maneuvers — the robot's real power and potential remain undiscovered by most owners — until now! This is the official Robosapien guide — endorsed by WowWee (the manufacturer) and Mark Tilden (the designer). This timely book covers all the possible design additions, programming possibilities, and "hacks"not found anywhere else. **$24.95**

Mechatronics for the Evil Genius
by Newton C. Braga



If you're fascinated by electronics and mechanics, this hands-on tour of the junction where they meet will bring you hours of fun and learning. Noted electronics author Newton Braga's *Mechatronics for the Evil Genius* guides you step by step through 25 complete, intriguing, yet inexpensive projects developed especially for this book. You will build your own mechanical race car, combat robot, ionic motor, mechatronic head, light beam remote control, and 20 other entertaining learning projects that take you to the heart of mechatronics. Each experiment builds on those before it so you develop a hands-on, practical understanding of mechatronics. **$24.95**

CNC Robotics
by Geoff Williams



Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **$34.95**

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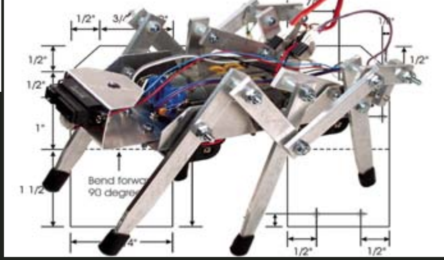
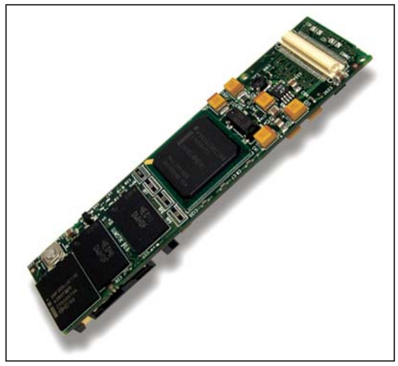


■ BY MIKE KEESLING

ROBO-POTPOURRI

YES FOLKS, IT IS TIME FOR ROBO-POTPOURRI. Robo-potpourri is the lost and found of my writing endeavors, a time to pick up little loose ends and such.



■ GumStix processor at 80mm x 20mm is really small.

BALL-BOT

The last year has seen the beginnings of my balancing robot project. In a nutshell, it is a holonomic drive sitting on a basketball. It is also a true thorn in my side to say the least. I am on my third mechanical revision, and have suffered arthritic pains and ghastly wounds over it. I could whine for several paragraphs, but that is neither useful or interesting. Let us say that I have put it in a box for contemplation, and will get around to it. I promise. My pitfalls are mostly due to utilizing water jet cut parts almost exclusively. A real machine shop at my disposal would alleviate most of my troubles.

ISOPOD CONTEST

I have gotten some interesting entries even though I managed to not include my email ... (DOH!!!!)

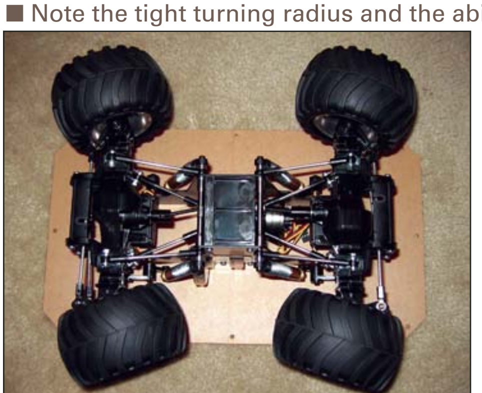
Please send your entries to blueeyedpop@sbcglobal.net

BACK TO MY ROOTS

A long time ago, I started messing around with PIC processors. They are truly inexpensive, reasonably powerful, and come in many more flavors than I was accustomed to. Later this year I will cover them in detail, but I really wanted to share some of my enthusiasm with you. I have gotten my hands on some really neat products from Hi-Tech, CCS, and MicroElectronica.

All of these vendors produce really wonderful products. There is no way I could do justice to you by covering only one. Each was packaged beautifully, and so far, playing with them has been pain free.

■ Note the tight turning radius and the ability to crab-steer.



FUTURE WORKS

My next big project is a real fun one. The basic concept is emulating pheromones with color. Ideally, digital noses would be developed into a mature technology, but as of now, they are still large and expensive. To simulate pheromone trails, I will be laying down trails of colored paper punches. In this way, different colors can simulate different signals, and the amount or frequency of occurrence can symbolize intensity.

The idea here is to avoid odometry and mapping in the classic sense, and concentrate on path following instead of path planning.

This one is going to involve a lot of neat hardware in addition to some interesting challenges.

For a mobile platform, I am going to be playing with some 1/18th scale monster trucks from Tamiya, specifically the TLT-1. Usually an R/C car is a less than ideal platform for robotics, but the TLT-1 has something special going for it. The TLT-1 has four wheel steering which enables a pseudo crabbing sideways motion or tight radius turning. I am also going to be playing with a four wheel platform from Lynxmotion. This will allow me to judge maneuverability of a typical differential drive against the Tamiya's. The drawback to this solution is the differential mechanisms, which will

need an application of very heavy grease to stiffen them up.

Actually, calling Lynx's 4WD2 typical is an injustice. This platform has an articulating chassis for better ground contact. Although it isn't as articulated as the Tamiya, it is simpler. Four motors ensure excellent traction. While meant for robot combat type utility, there is a lot of value in keeping all four wheels on the ground.

On a side note, next time you buy R/C gear, consider the smaller, more personable hobby shops. They have the knowledge the big chains don't and can really help you make intelligent decisions. My local hobby shop, Robin's Hobbies (www.robinshobby.com/) has been around for decades, and is a real treasure trove.

BRAINS

The core of my processing power will be the Connex from GumStix.com The GumStix line of products is really interesting, and a big stretch for me in terms of my abilities.

The GumStix are based on an Intel Xscale PXA255 running at either 200 or 400 MHz. The stretch for me is that they run Linux, and will be programmed with C. I won't be forgetting my FORTH roots completely however, as I will be using a PlugaPod from New Micros, Inc., to provide a lot of the hardware interfacing.

Granted, I could do a lot of stuff without an operating system, but it is handy. More importantly for me, it allowed me to interface with the Linux geeks at work, and give them a creative outlet that is different from the usual hum drum (not that my work is boring, mind you!).

■ Lynxmotion 4WD2 articulated platform.

This is a really big challenge for me, but I am fortunate to have a bunch of Linux people at work to help me through the rough spots. In preparation, I have installed Debian Linux on a few old machines, like Celeron 600 laptops with 64mB RAM, and have been learning the shell commands which are much like DOS, and therefore somewhat familiar to me.

Linux has been really fun, sort of liberating actually. I don't have to rely on a commercial vendor for software, and I personally have had to do relatively little messing around to get my machine running. True, it isn't as flexible as other commercial operating systems as far as its windowed experience is concerned, but I gain a lot in other respects. I am not ready to reformat my main PC, but you can bet the next hard drive upgrade will have a Linux partition on it.

One area that has given me the greatest gratification is building GNU compiler tool-chains. This may be an indication of my ignorance, but I struggled to get an ARM tool-chain up and running on a commercial, windowed operating system for two weeks. When I did get it running, I was so jaded I diverted my attention to other projects. Additionally, to get it to run requires you to install Cygwin or Colinux on your windowed operating system anyhow, so why not go to the source and install Linux.

Overall, I am really excited to embark on this new year, and look forward to sharing my experiences with you. Just watch your step, there may be robots afoot. **NV**

SHOWCASE

Continued from page 6

CAN HAVE IT BOTH WAYS

I have a hard copy subscription to *Nuts & Volts*. I intend to keep my hard copy version. Tonight, I went to see the online version. I really appreciate being able to have both versions available to me. It is very convenient to:

1) See the new edition before I get it in the mail.
2) Be able to use the links in the magazine simply by clicking on them.
3) Be able to "take it with me" if I am traveling with my laptop.

Thanks for making this available to the hard copy subscribers at no additional cost. Keep up the good work.

Tom Bohacek

SWITCH THE LABEL

I just read the article titled "The Perception Circuit" in the January issue. I just wanted to suggest a label for SW1. The switch could be labeled the Male/Female switch. When in the male position, the inputs cause a decison to be made and displayed. When in the female position, the inputs cause a decision to be made but the device changes its mind over and over again after that first decision is made. (Please note that this is meant as humor.)

Craig Hermann

HAPPY CAMPER

I am extremely pleased with your magazine, which seems to improve with each issue. As an electronics professional, I find it is a goldmine of new ideas. Even the clever "No Volts" weather instrument enclosures (January '06) can be adapted to many other electronic uses. I have also enjoyed the many thought-provoking historical articles such as the Crosley "Readio." You are right on track for the 21st century!

Bob Kramer

PART-EN ME

It sure would be nice if the author would have included a parts list for the PIC project as shown in Figure 4 on page 76 of the January '06 issue. Since I'm new to electronics, it would help if I knew what to purchase.

Charles W. Bartsch

A parts list is available on the Nuts & Volts website at www.nutsvolts.com

Continued on page 77

20TH ANNIVERSARY PRICE REDUCTION

In celebration of the 20th anniversary since its founding, the Power Sources Manufacturers Association (PSMA) has announced a special offer on Nathan Grossner's classic treatise, *Transformers for Electronic Circuits — Second Edition*. Originally priced at $95, this important text may now be purchased directly from PSMA for $75. PSMA members are offered an additional $20 discount. Order directly online at **www.psma.com** or **www.ejbloom.com**

This text is a complete, one-stop guide to transformer and inductor design and applications for everyone who designs, builds, or uses power magnetics components. Throughout this book, the author combines analysis and synthesis and all theory is related to the solution of real-world problems.

Sections of the text provide guidance in the use of transformers and inductors in power electronics and in digital and pulse circuits. Also included is design information about other forms of high-frequency magnetics such as transmission-line transformers, hybrid transformers, ferroresonant tranformers, flyback converter magnetics, and inductors used in switch mode power converter designs.

Special attention is given in the book to the proper control of dielectric stress, corona, and thermal factors in high-voltage magnetics designs. Modeling methods for magnetic parts are also included and treated in some detail. This book is an essential reference book for any engineer involved in the design and development of modern-day magnetic components.

According to Joe Horzepa, managing director of PSMA, "Grossner's book should be an essential part of every power supply designer's technical library and thanks to PSMA, it is once again available after being out of print for several years. Now, in celebration of the 20th anniversary of our organization, we're lowering the price as a thank you to the industry we serve."

PITTMAN 35MM INCREMENTAL ENCODER FOR DC MOTORS AWARDED PATENT

The PITTMAN® 35mm ROSE (Reflective Optical Sensing) incremental encoder for brush-commutated and

brushless DC motors has been awarded US Patent No. 6,963,064. Instead of requiring discrete modules for individual line-count applications, this newly patented encoder provides an unprecedented capability to achieve multiple line counts utilizing only one module.

The PITTMAN encoder has been configured to fit a variety of brush-commutated and brushless DC motor products available from most manufacturers. Encoders can be added to any motor or gearmotor with wires or side-exiting power terminals and can be plastic-housed or open air. They can be factory-mounted or prepared for mounting in the final stages of end-product assembly.

This encoder features an innovative PC board-based modular design and multi-tracked code discs to enable the widest range of resolutions (192, 200, 250, 256, 360, 400, 500, and 512 counts per revolution) using minimal parts. The PC board consists entirely of surface-mount components, which promotes flexibility in low tooling costs and quick turnaround to accommodate custom control electronics.

The encoder is an incremental, non-contacting rotary-to-digital feedback device translating real-time shaft angle, speed, and direction of rotation to TTL-compatible outputs. Outputs are two-channel, in quadrature, with medium resolution encoding. Signal conditioning options (all on board) include an RS-422 high-speed differential line driver, pull-up resistors, and additional filtering capacitors.

ADVANCED CIRCUITS GOES LEAD-FREE ON ALL PCB PROTOTYPES

Advanced Circuits, a source for quick-turn printed circuit boards, has announced that all prototypes will now be fabricated using lead-free solder as a plating finish. The lead-free HAL finish provides an enhanced solderable finish for assembly and meets all legislation requirements for the European Union's RoHS Directive six months ahead of the July deadline.

"Advanced Circuits is one of a limited number of PCB manufacturers in the US offering a complete lead-free solder alternative," said Tony Garramone, corporate training manager at Advanced Circuits. "We strive to stay ahead of the curve and provide our customers with the most current technology. Any printed circuit board that we produce whether prototype or production is free of mercury, cadmium, hexavalent chromium, polybrominated biphenyls, or polybrominated diphenyl ethers."

Advanced Circuits' lead-free boards are produced using a lead-free alloy of 99.3 percent tin and 0.6 percent copper with a trace of nickel (SN100CL). This solder offers an alternative to more expensive lead-free finishes. **NV**

■ LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

●○○○ . . . . Beginner Level

●●○○ . . . . Intermediate Level

●●●○ . . . . Advanced Level

●●●● . . . . Professional Level

BUILD A HIGH SPEED PHOTO FLASH TRIGGER

During the early 1930s Harold "Doc" Edgerton, a faculty member of the Massachusetts Institute of Technology (MIT), started experimenting with strobe lights, better known today as electronic photo flashes.

Today, the use of a photo flash is a ubiquitous occurrence wherever cameras in low light conditions are being used. On those early days however, photo flash use was limited to cumbersome magnesium flashes, not to the modern, all-electronic devices we now take for granted.

Since the light's output duration of an all-electronic strobe light is so exceedingly short, Dr. Edgerton would use them to freeze movement of very high speed events, allowing them to be discerned by the human eye or captured with photographic equipment.

He took many famous photographs, including that of a speeding bullet piercing an apple, or the exceedingly beautiful "Coronet," where a milk drop forms a delicate crown on a pool of milk. "Doc" Edgerton's work certainly revolutionized the photographic field. I was inspired by his work.

There are many ways to trigger a flash so it's synchronized with the event one wants to capture. Perhaps the simplest is to trigger it by the sound produced by the event one wants to capture, whether this is a bursting balloon or a water splash. This has the added advantage that sound travels at about 1 ft/msec, and thus by adjusting the distance of the microphone to the event, the appro-

■ FIGURE 1. Balloon bursting shows water hemisphere suspended in mid-air.

■ FIGURE 2. A cascade of water as a pebble is dropped in a bucket.

priate delay can be easily set. This is important as some events may be timed for maximum photographic effect.

A pair of photos using this technique is show in Figures 1 and 2.

Circuit Description

This is quite a simple circuit, as shown in the schematic of Figure 3. M1 is a 4.5 volt electret microphone capsule, which is biased by R1, R2, and R12. This bias, along with the audio signal, is fed to op-amp U2. The gain of this stage may be varied from 6 to 56 by adjusting potentiometer P1. To simplify the layout, the pot has an included on/off switch to power the circuit from the +9V battery terminals. C2 and C3 decouple noise.

The amplified audio signal is capacitively coupled via C4, to a window comparator comprised of U3 and associated circuitry. R13 and R14 biases U3 at mid supply, whereas R5, R6, R7 provide the window. Whenever the DC level plus the audio signals exceed either voltage at pins 3 or 6, one of the output pins 1 or 7 is pulled low. Since this is a wired-OR connection, the falling edge signal triggers the first monostable comprised of U4a, C5, and R9. This provides a 100 millisecond drive to MOSFET Q1, which turns on and establishes a path for the external flash to be triggered.

The second monostable, comprised of U4b, C6, and R10, provides a one-second blanking pulse. This second monostable is triggered by the negated output of the first one, which also blinks the LED to provide visual information of the circuit's actions. This blanking pulse is important, because I found — the hard way — that many events have multiple sound pulses, from secondary breakage or even echoes. For instance, glass breaking produces literally dozens of sounds as it shatters. These secondary sounds provide multiple triggers to the flash unit, which results in a severely overexposed picture.

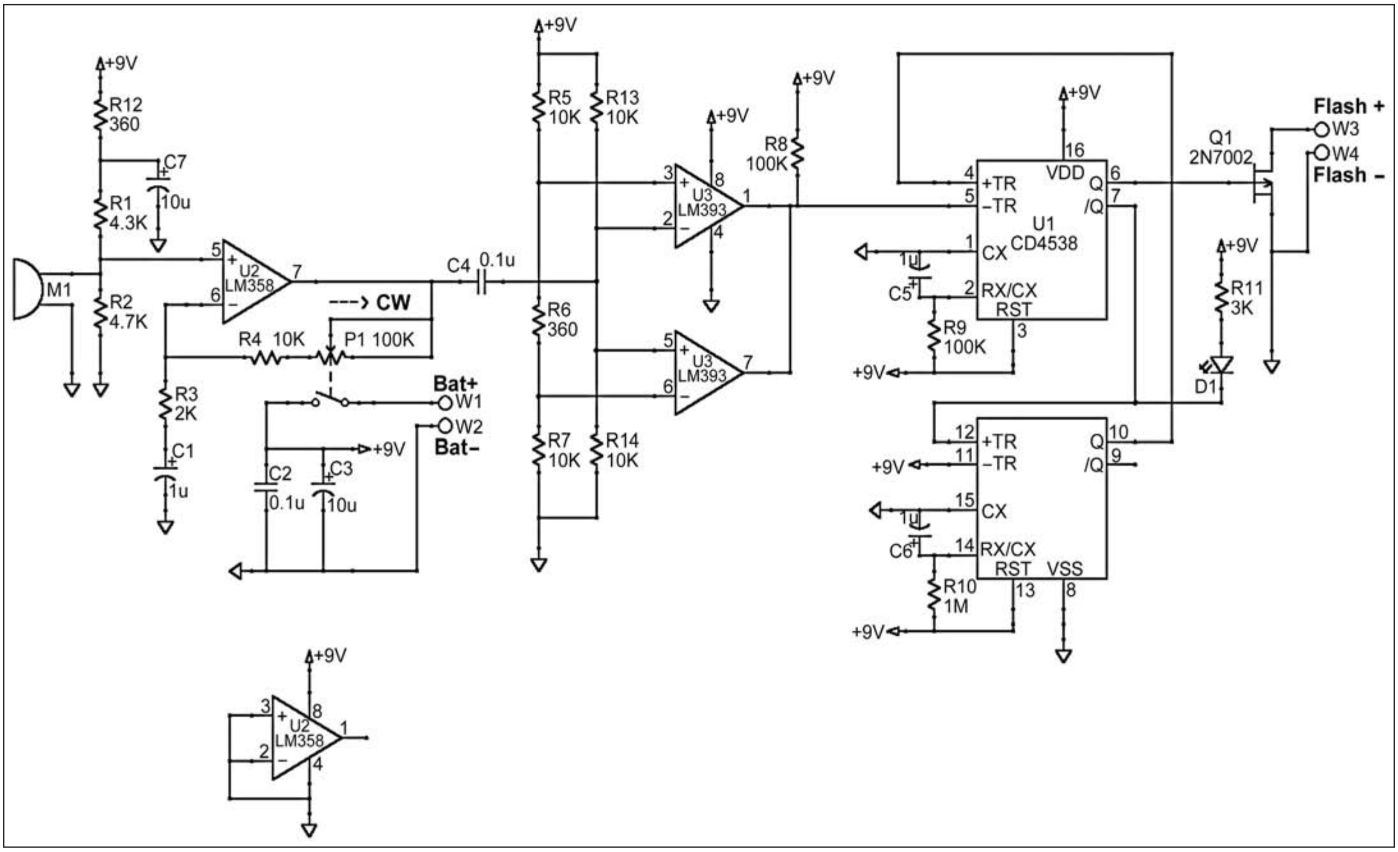
The MOSFET is a 60 volt rated device, which means that you can safely trigger the newer flashes for digital cams or the older flashes used for 35mm film cameras, which have a far larger open circuit voltage.

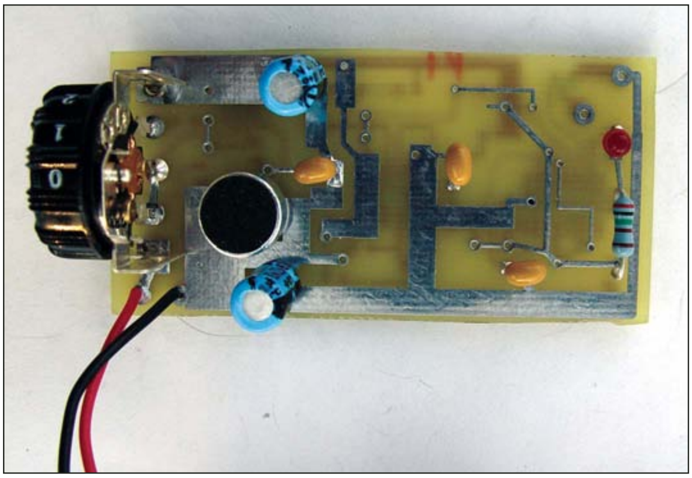
Building the Circuit

The project is simple and straightforward, and can be built by any of the common breadboarding methods. There are no critical layout areas, other than to ensure that the microphone capsule is close to the op-amp for minimum noise pickup.

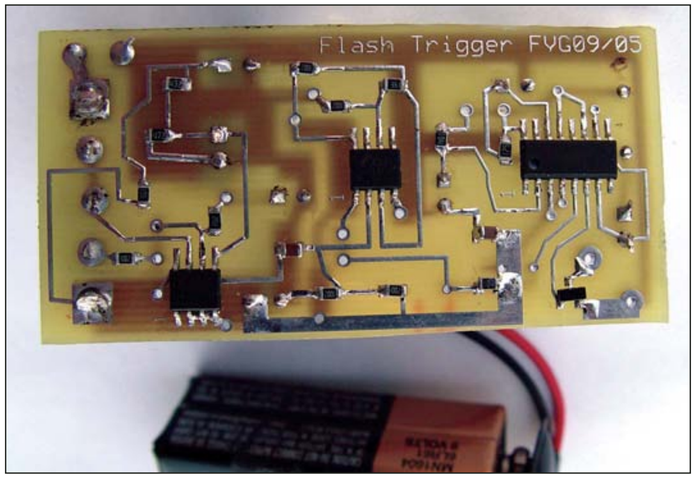
Please observe the normal handling and soldering procedures for CMOS devices. I've designed a small, double-sided PCB (shown on the *Nuts & Volts* website; www.nutsvolts.com) for a straightforward assembly. Since I desired a small footprint — basically

■ FIGURE 3. Project's schematic. Only three ICs are required.





■ FIGURE 4a. Project's top view.



■ FIGURE 4b. Project's bottom view. PCB is not much larger than a nine-volt battery

shadowing that of a nine-volt battery — this project uses both leaded and Surface Mount Technology (SMT) devices, which are evident in the photos of Figures 4a and 4b, respectively. I chose moderately-sized SMT devices, so as not to tax your soldering skills too much. Please note that for ease of assembly, the SMT devices must be soldered first.

A note on capacitors C1, C5, and C6: *These are 1 microfarad devices, and they are available as either a ceramic or electrolytic type. You can use either one but the ceramics are the preferred devices. However, if you choose an electrolytic, pay attention to the polarity signs. C3 and C7 are (because of their value) found almost exclusively as electrolytics, so do pay attention to polarity.*

Since the circuit has so much gain, it is important to isolate the microphone from the circuit board. Do not install it flush against it. Rather leave a 0.1" to 0.2" gap, and then fill that gap with hot melt glue for mechanical stability. Speaking on the subject of microphones, you may wish to mount it remotely. If you do so, please remember that electret microphones are polarized. The square pad on the board is positive. Use shielded cable for the hookup. Please note: *This project is not designed to work with dynamic type microphones.*

The board connects to the external flash with hookup wire to the flashes' hot-shoe via an inexpensive adaptor (see Figure 5) or, in some instances, the flash may have a phono plug for external triggering (see Figure 6). You may find out that many times the flash units or hot shoe adaptors have a coaxial type connector called a PC connector, somewhat unique but very common to the photo industry.

This connector is clearly visible in the hot shoe adaptor photo. Prior to attempting to trigger the flash with this circuit, you must determine the polarity. Do this by powering-on the flash unit by itself, then connect the hot shoe adaptor and identify the (+) and (-) leads with a multimeter in the volts range. Then connect them to the proper PCB pads, W3 and W4, respectively. Likewise, the battery's (+) and (-) leads connect to W1 and W2.

Testing the Circuit

To initially ensure that the circuit is working properly, you do not need a flash unit or a camera. After you have double-checked parts placement and the soldering (especially important for the SMT devices), connect the nine-volt battery, set the potentiometer at maximum gain, and clap your hands in front of the project. You'll see the LED flash.

■ FIGURE 5. Flash hot-shoe adaptor. Photo courtesy of B&H Photo and Video.

■ FIGURE 6. Some flashes provide a mini-phono side connector for external triggering.

Try adjusting the pot to other settings, and then clap at different distances. You'll get a feel on the required sensitivity. Now connect and power-up the flash, and after its "ready" light comes on, repeat the experiment. The flash should trigger with the clapping, which means now you are set to go.

Remember that this is a combination electronic/photographic project. Once the electronic portion of the project is up and running, you must prepare your photography setup. Besides this completed project, you'll require the following:

1. An external, non-dedicated flash. Dedicated flash units, designed to work specifically with particular camera models, derive syncing, exposure, and sometimes power from signals coming the camera itself.

2. A camera that allows full manual control. It could be either film or digital, SLR or fixed lens, but the important characteristic is that both manual focus and manual exposure control is required.

3. A tripod or something sturdy to keep your camera steady while your hands are busy with other things.

To actually capture the event, your camera setup has to be in an area of very dim lighting. Complete darkness is best. The reason being that you must open the shutter, initiate the event (pinching the balloon, dropping the bottle, etc.) which will create the noise that will trigger the flash itself, then close the shutter immediately after. The reason that the shutter must be open prior to the event to be captured is that all cameras suffer from shutter lag, which is the time from when the camera is triggered to take a picture, to the actual image capture. Digital cameras are especially at fault in this respect, but even a good film camera may have a delay — however minimal. This delay can be excessively long if the event one is attempting to capture is measured in fractions of milliseconds. It becomes even worse if the camera attempts to auto focus, then the shutter lag becomes an eternity. Therefore, you must manually set the camera's focus.

Again, it goes without saying, that when attempting any photo setup which you have previously not done, a few trial pictures are required beforehand to fine tune it. You'll have to adjust focusing, exposure settings, composition, flash level, etc. This is a photography project after all and one that benefits enormously from digital cameras and their instantaneous feedback. **NV**

PARTS LIST

(All parts available from Mouser Electronics; **www.mouser.com** / 800-346-6873.)

RESISTORS	PART NO.
❑ R1 — 4.3K, 5% 0805 SMT	260-4.3K
❑ R2 — 4.7K, 5% 0805 SMT	260-4.7K
❑ R3 — 2K 5% 0805 SMT	260-2K
❑ R4 — 10K, 1% 0805 SMT	292-10K-RC
❑ R5 — 10K, 1% 0805 SMT	292-10K-RC
❑ R6 — 360, 5% 0805 SMT	260-360
❑ R7 — 10K, 1% 0805 SMT	292-10K-RC
❑ R8 — 100K, 5% 0805 SMT	260-100K
❑ R9 — 100K, 5% 0805 SMT	260-100K
❑ R10 — 1M, 5% 0805 SMT	260-1M
❑ R11 — 3K, 5% 1/4W	660-CF1/4L3K
❑ R12 — 360, 5% 0805 SMT	260-360
❑ R13 — 10K, 1% 0805 SMT	292-10K-RC
❑ R14 — 10K, 1% 0805 SMT	292-10K-RC
❑ P1 — 16mm linear taper potentiometer 100K w/ switch	311-1700-100K
CAPACITORS (all 10% tolerance)	
❑ C1 — 1µF, 50V (*see text*)	581-SR225C104KAA
❑ C2 — 0.1 µF X7R ceramic 0805	581-08055C104K
❑ C3 — 10 µF, 16v electrolytic	647-UVR1C100MDD
❑ C4 — 0.1 µF X7R ceramic 0805	581-08055C104K
❑ C5 — 1µF, 50V (*see text*)	581-SR225C104KAA
❑ C6 — 1µF, 50V (*see text*)	581-SR225C104KAA
❑ C7 — 10 µF, 16V electrolytic	647-UVR1C100MDD
SEMICONDUCTORS	
❑ M1 — 4.7 volt electret microphone	252-EM9745P-40
❑ U1 — CD4538 dual CMOS monostable SMT	512-CD4538BCM
❑ U2 — LM358 dual general-purpose op-amp SMT	512-LM358AMX
❑ U3 — LM393 dual comparator SMT	512-LM393MX
❑ D1 — Miniature red LED	606-430H1
❑ Q1 — 2N7002 N-channel MOSFET	689-2N7002
MISCELLANEOUS	
❑ Potentiometer thumbwheel knob	450-0009
❑ Nine-volt battery clips	121-0424/I
❑ Perfboard or dedicated PCB	

Photography — Besides the camera with the requirements outlined above, you'll also require a camera tripod and an external flash. If the flash does not have an external trigger input, you will require purchasing a hot-shoe adaptor, as pictured in Figure 6. You may already own or have access to these. If not, B&H Photo and Video (**www.bhphotovideo.com** / 800-309-4374) is an excellent source of photographic equipment and accessories.

If there is enough interest in this project, I may sell a PCB or kit of parts. Please contact me at fernando.v.garcia@netzero.com

KITS DOWN UNDER

Down town, down under in Sydney Australia!
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Smart Card Programmer Kit

KC-5361 $34.95 + post & packing

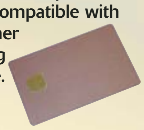
Program both the microcontroller and EEPROM in the popular Gold, Silver and Emerald wafer cards. Cards need to conform to ISO-7816 standards, which includes the ones sold by Jaycar. Powered by 9-12VDC wall adaptor or 9V battery. Instructions outline software required which is freely available on the Internet. Kit supplied with PCB, wafer card socket and all electronic components.
PCB measures: 141 x 101mm

Jaycar cannot accept responsibility for the operation of this device, its related software, or its potential to be used in relation to illegal copying of Smart Cards in Cable T.V. set top boxes.

Wafer Card

ZZ-8800 $2.25 + post & packing

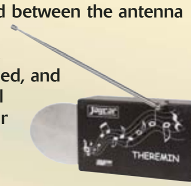
This is a multi-chip 'smart card' based on the PIC 16F84A and is coupled with a 24LC16B EEPROM, compatible with most reader/programmer units available including the programmer above.



Theremin Synthesiser Kit

KC-5295 $34.95 + post & packing

The Theremin is a weird musical instrument that was invented early last century but is still used today. The Beach Boys' classic hit "Good Vibrations" featured a Theremin. By moving your hand between the antenna and the metal plate, you can create strange sound effects. Kit includes a machined, silk screened, and pre drilled case, circuit board, all electronic components, and clear English instructions.



9VDC wall adaptor required (Jameco #252751 $10.95).

Universal High Energy Ignition

KC-5419 $55.25 + post & packing

A high energy 0.9ms spark burns fuel faster and more efficiently to give you more power! This versatile kit can be connected to conventional points, twin points or reluctor ignition systems. Includes PCB, case and all electronic components.

New & Improved

"Clock Watcher's" LED Clock Kits

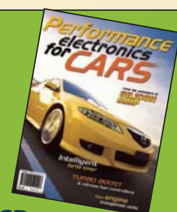
KC-5416(blue) $110.25 + post & packing
KC-5404(red) $82.95 + post & packing

These clocks are hypnotic!
They consist of an AVR driven clock circuit, that also produces a dazzling display with the 60 LEDs around the perimeter. It looks amazing, but can't be properly explained here. We have filmed it in action so you can see for yourself on our website www.jaycarelectronics.com! Kit supplied with double sided silkcreened plated through hole PCB and all board components as well as the special clock housing! Available in Blue (KC-5416) and Red (KC-5404).

High Performance Electronic Projects for Cars

BS-5080 $14.95 + post & packing

Australia's leading electronics magazine Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers. The book includes all instructions, components lists, color pictures, and circuit layouts. There are also chapters on engine management, advanced systems and DIY modifications. Over 150 pages! All the projects are available in kit form.



Smart Fuel Mixture Display

KC-5374 $17.95 + post & packing

This new 'smart' version has a few additional touches such as, auto dimming for night driving, emergency lean-out alarm, and better circuit protection. Another great feature, is the 'dancing' display which operates when the ECU is operating in closed loop. Kit supplied with PCB and all electronic components.

- Car must be fitted with air flow and EGO sensors (standard on all EFI systems) for full functionality.

Recommended box UB3 $1.95 each

High Range Adjustable Temperature Switch with LCD

KC-5376 $44.50 + post & packing

Heat can be a major problem with any car, especially modified and performance cars. The more power, the more heat, so you need to ensure you have adequate cooling systems in place. This temperature switch can be set anywhere up to 2192°F, so it is extremely versatile. The relay can be used to trigger an extra thermo fan on an intercooler, mount a sensor near your turbo manifold and trigger water spray cooling, or a simple buzzer or light to warn you of a high temperature. The LCD displays the temperature all the time, which can easily be dash mounted.

Ideal for monitoring exhaust & brake temperature - 2192°F RANGE!

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The sensor for the micro gust thermal anemometer (MGTA) is a LM399 voltage reference.

The LM399 is a remarkably precise temperature stabilized zener diode reference with a nominal voltage of about 6.9V. The LM399 zener diode structure is contained within a tiny temperature controlled oven. While the initial zener voltage can vary from about 6.6V to 7.3V, once biased to between 1 and 10 milliamps, the zener voltage can be very stable (to microvolts) over temperature.

MICRO GUST THERMAL ANEMOMETER (MGTA)

At Geller Labs, we use LM399s in our high performance, low cost voltage standards for hobbyists, schools, and amateur scientists as the 01HS high stability option. Even with its special thermally insulating cover, all of our products using the LM399 are contained within an enclosure — such as a plastic box — to further shield the LM399 from room air currents.

One day it occurred to me to stop fighting the insulation problem and to investigate the possibility of using an LM399 as a sensor to measure tiny air currents on the surface of a lab table. An LM399 was removed from its plastic thermally insulating case and powered up on the bench. A digital multimeter (DMM in the current mode) was connected in series with the heater (pins 3,4) power source. As you will see, we only need the oven section of the LM399 to make a measuring instrument. I blew a puff of air towards the LM399 from a couple of feet away and was pleasantly surprised when the DMM clearly responded a second or so later. As an avid electronics hobbyist, I set to work to design a simple scaling circuit and amplifier to make a workable front end for a thermal anemometer.

A thermal anemometer is a wind measuring instrument based on a heated element, such as a heated wire. The underlying principle of operation is that the resistance of the wire changes as heat is removed by the air flowing over the wire. While most thermal anemometers end up as relatively complex circuits such as Wheatstone bridges inside of analog closed servo loops, our LM399 version turns out to be remarkably easy to build. Since it responds to very tiny air currents, I call it a Micro Gust Thermal Anemometer (MGTA).

■ The assembled board.

Procedure — Building and Fabricating

The first step to build an MGTA is to disassemble an LM399H. Always wear safety glasses when taking something apart! One disassembly method is to gently squeeze the LM399 in a vise or with pliers. As the top begins to buckle and release, gently pry it off with a small screw driver. Try to minimize damage to the thermally insulating cover. You may even want to mount the LM399 through its bottom cover section, so the cover can be slid back up over the exposed metal can (TO-46 package) to create a second less sensitive scale. A third wind scale could be made by reinstalling the cover section.

The next step is to build the amplifier circuit. It can be assembled using any reasonable construction method ranging from a hobbyist's perf board to dead bug

prototyping (gluing parts to a copper surface and air wiring them with all commons soldered to the copper ground plane) to a full printed circuit board. The layout is shown on the *Nuts & Volts* website (**www.nutsvolts.com**) for do-it-yourself PCB builders, or we offer a manufactured PCB (see parts list).

Low frequency analog construction is pretty forgiving. The only caution is to mount the resistors as close as practical to the op-amp input terminals (keeping connections relatively short). Also, be sure not to create any large thermal heatsinks near the LM399 leads, so as not to interfere with its temperature regulation system by needlessly draining off heat intended to maintain a constant temperature within the LM399 case.

The circuit will work with many standard types of dual op-amp that can operate reasonably close to the power supply rails. Some op-amps will give differing end scale values depending on how close their output stages can go to the positive rail or to ground. The recommended National Semiconductor LM6132BIN gives exceptionally good performance to both rails. The circuit also works fine — albeit with a very slightly reduced range — with the TI OPA2277 or the Analog Devices OP-297 dual op-amps. Older generation bipolar op-amps that cannot operate close to the rails are less desirable for this application. For example in this application, an LM1458 can only operate over a greatly reduced output scale starting around 6V. See the sidebar on op-amp rail-to-rail performance.

A socket is recommended both for troubleshooting and for experimenting with different types of op-amps. I recommend using all 1% metal film resistors for instrument type repeatable measurements, but any type of resistors with the correct values can be used just to see the circuit in operation.

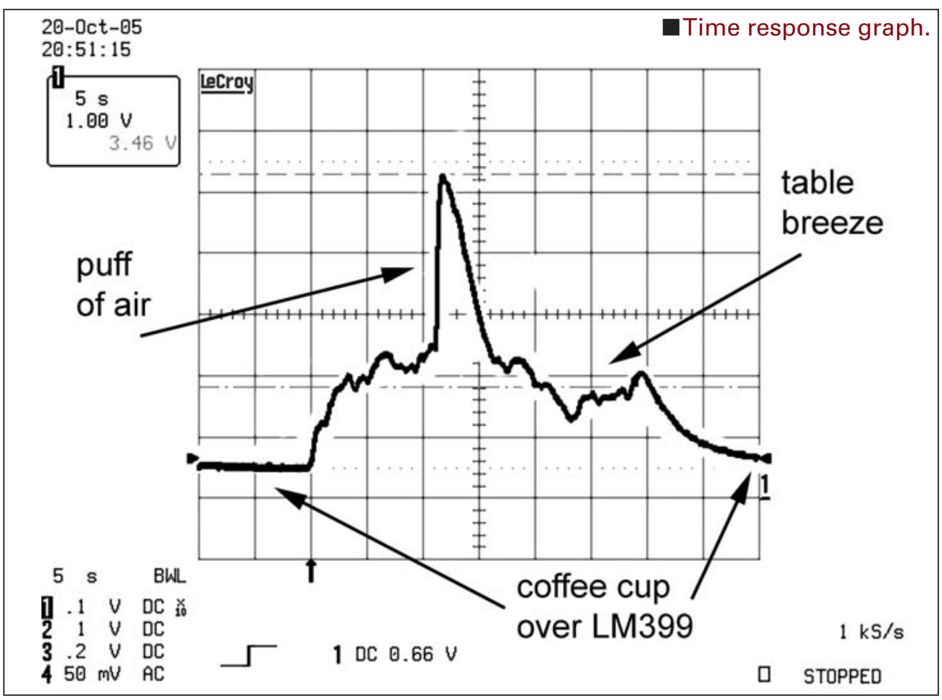
I mounted the LM399 directly on the board without trimming the leads so that it stands up as high as practical. The LM399 can also be fashioned as a probe using a twisted shielded cable. To make a probe, connect the oven (-) to one wire (black), the oven (+) to the other wire (red), and do not make a connection to the shield at the sensor side. At the circuit board side, connect the shield and the black wire to circuit common and the oven (+) wire to the junction of R1/R4 as if the LM399 were mounted on the circuit board.

■The LM399.

Testing

CAUTION: THE EXPOSED LM399 IS HOT. DO NOT TOUCH THE LM399. It is not hot enough to melt solder or even to boil water, but it will give you a nip if you touch it. DO NOT DO THIS PROJECT IN AN EXPLOSIVE ATMOSPHERE OR NEAR VOLATILE (flammable) CHEMICALS. To be safe, do not power it up anywhere you wouldn't use a soldering iron (even though it runs quite a bit cooler).

Quick start instructions: Power up the MGTA board with a +15V (single supply operation) and connect a DMM (volts) to the MGTA board output. If you have an ammeter available to measure the power supply load current to the board, the load current should be under 75 mA. The power supply load will stay near a relatively high level (about 60 mA or higher) for several seconds while the internal LM399 heater brings the oven up to operating temperature. Once at operating temperature, the board draws about 20 mA at no wind. Cover the LM399 with a Styrofoam coffee cup (I like Dunkin Donuts® medium cups). Use the trimpot to set the output to just above where your op-amp starts to operate (see the sidebar on rail-to-rail



■Time response graph.

Applications

The MGTA has many possible applications, ranging from whimsical to serious engineering uses. On the fun side of things, an MGTA could be the basis for an indoor wind chime. It is very sensitive to normal room air currents. The MGTA voltage output can be digitized in as few as eight bits to generate digital values representative of the micro gusts and breezes in a room. Many microcomputers include internal eight or 10 bit analog-to-digital converters (ADCs). These values could be used by a microcontroller to play wind chime-like sounds and tones, musical notes, or melodies and songs.

An MGTA can also be used to make a sensitive leak detector for finding hidden air leaks around doors or windows. The circuit can also monitor air currents on a lab table top for identifying the effects of small winds (breezes) on circuits under test. It could also serve as a wind velocity indicator in a low velocity wind tunnel for paper air planes, or possibly as an air speed indicator for slow moving model gliders. An MGTA can also be useful to study the thermally insulating properties of materials including small insulators and coffee cups.

op-amps).

For the recommended LM6132BIN, that's around 0.5V, for the OPA2277 or OP-297 zero wind is around 2.5V. If you are unable to set the zero wind value, power down and read the circuit description and troubleshooting sections below. If the output voltage looks good, take off the coffee cup. The output voltage should jump up by about one or two volts, depending on the micro winds near the LM399. If the MGTA is still checking out okay, blow a tiny puff of air over the LM399. You should see a noticeable change in the output voltage above 1V. Higher breezes cause changes over several volts. The instrument reaches full scale (saturation) in a strong breeze.

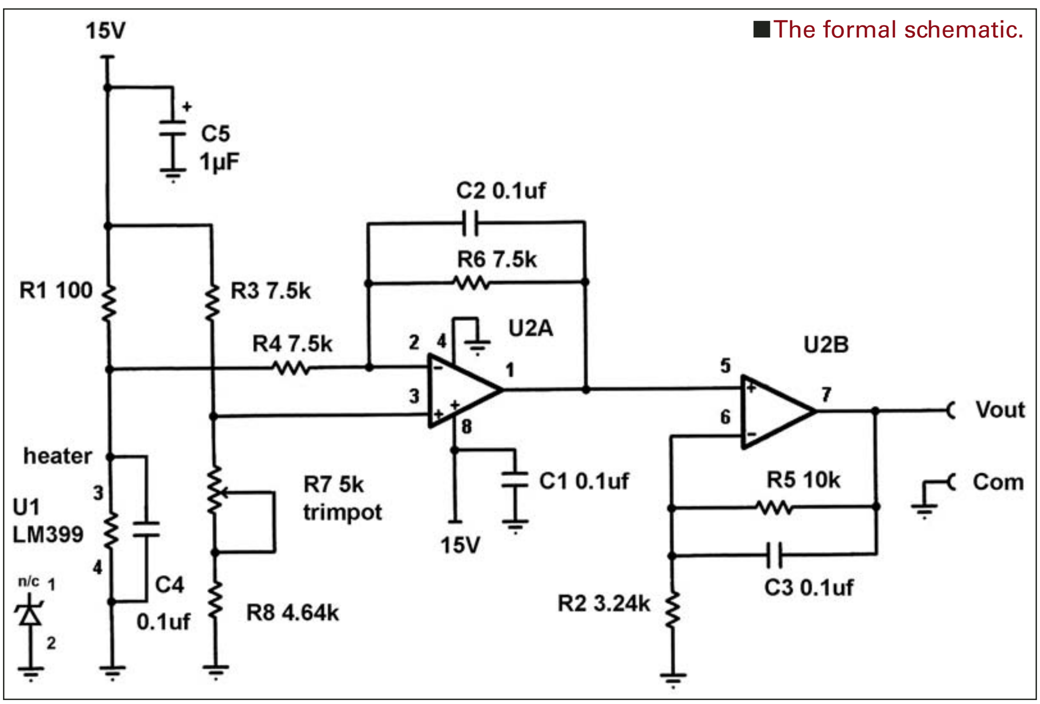
A digital oscilloscope display (or a chart recorder) can show the time response of the MGTA. With a Styrofoam coffee cup rested over the LM399 (but still leaving the trimpot exposed), the output voltage should be at the zero wind set point. With the coffee cup removed, the MGTA measures the micro gusts over the work table surface. And, after a puff of air is blown at the LM399, there can be an output voltage rise ranging from mV to several volts over less than one second, followed by a decay of several seconds (as dominated by the LM399 oven time constant).

Slow Start Instructions (Troubleshooting)

Apply power to the circuit. Set the regulated power supply voltage to within about 100 mV of 15V (14.9V to 15.1V). You should be able to set about 6.9 V (±0.5V) at pin 3 of U2A using the trimpot.

Next, with no wind (coffee cup over LM399), check the voltage between the heater (+) connection and common. At no wind (coffee cup installed), you should see about 13V (±0.5V). At full wind (blow harder), this voltage drops to about 9.2V (±0.5V). If you feel an urge to touch the can, don't (*IT IS HOT*). Instead, use something like the top swivel end of a jeweler's screw driver to force the oven heater full on (but only for a moment so as not to damage the LM399!).

Once the LM399 front end is working, move to pin 1 of the op-amp. This first stage output should vary from roughly 0.1V (higher with non rail-to-rail op-amps) to 4.5V as measured to common from no wind to a full scale breeze. And finally, pin 7 of the dual op-amp should range from about 0.5V no wind (higher with non rail-to-rail op-amps) to about 14V at a full scale.



■The formal schematic.

Circuit Description

R1 can serve dual roles as both the LM399H heater current sense resistor and as a current limiter to prevent a dangerous overheating condition in the event of a short in the LM399. The voltage at the node of R1 and the LM399 heater typically ranges from 13V at no wind (with the coffee cup over the LM399) to 9V full scale (a very small breeze indeed!). R1, the 100 ohm sense resistor, causes a voltage drop from the 15V rail proportional to the LM399

heater current.

Instead of being connected to actual common, the non-inverting input of U2A is connected to a voltage divider at a bias voltage of about 7V. Thus, U2A is an inverting amplifier offset by the 7V provided by the divider. Since the divider output is only connected to the high impedance non-inverting input, it is not significantly loaded by the op-amp. The 7V offset serves as a reference or bias point about halfway on a scale of the 15V power supply, allowing a dual power supply op-amp to function on a single supply voltage. The exact value of the divider voltage can be calculated using the equation: Vdivider = 15V x ((R7+R8) / (R3+R7+R8)).

In my first design, I used the LM399 (U1) 7V reference diode, biased to roughly 1 mA reverse zener current by a resistor to create a bias for the first amplifier. But then it turned out that a simple resistor divider bias circuit improves the MGTA performance by reducing sensitivity to changes in power supply voltage. Using this approach, a zero wind set point can be conveniently added using a fixed resistor in series with a trimmer resistor in the lower leg of the bias voltage divider.

It is interesting to note that if you think of the schematic diagram as having "rubber band" connections and move the parts around in your head or on paper, you can see that the first stage amplifier is a conventional one op-amp instrumentation amplifier design, even though all of the resistors are not perfectly matched when the combination of R7 and R8 are not set exactly to 7.5K.

Otherwise, this first stage is an inverting amplifier with a gain of R6/R4. Note that if the input voltage at R4 was 7V, the output voltage of this stage would be 7V. For the typical input range of voltages noted above, the output voltages for this stage range from about 0.1V (higher for a non rail-to-rail op-amp) at no wind (coffee cup in place) to just under 5V full scale (a small breeze).

The gain of the U2A stage is near unity given by R6/R4. R4 and C2 also act as a low pass filter to reduce noise at the output (frequency determined by R6/C2). The second amplifier stage, U2B, is a non-inverting amplifier with a gain of (1+(R5/R2)). A second RC pole is created by R5 and C3 for further noise reduction. The two cascaded single pole filters roll off at a couple of hundred Hz as a noise filter. The system response is dominated by the LM399 internal heater loop with a time constant on the order of two or three seconds.

The typical output range from an MGTA board is around 0.3V (2.5V or higher with most non rail-to-rail op-amps) with the coffee cup thermal guard installed and near 14V for full scale (a slight breeze). The MGTA output signal is thus a voltage level

Op-amps and Rail-to-Rail Performance

The "rails" or positive and negative power supply voltages are the limits of the voltage range available in an amplifier circuit. In a traditional op-amp circuit powered by ±15V power supplies (more commonly ±5V today), the rails are ±15V, or the positive rail is +15V and the negative rail is -15V. The typical "head room" needed for proper op-amp operation ranges from one to four volts. That is, the input or output voltages should generally not exceed ±11V where the allowable range is within 4V of the rail.

Op-amps have two ratings: a maximum input range and a maximum output range.

The input range is called the input Common-Mode voltage range and the output range is often called the output voltage swing. Both the common mode input range and output swing have two values: a minimum voltage (how close the op-amp can operate to the lower rail) and a maximum voltage (how close it can operate to the upper rail). While many amplifier circuits cannot operate close to the rails, rail-to-rail op-amps are the exception. An op-amp rated as rail-to-rail generally can accept an input voltage very near or at the rails (the input common mode range), and an output voltage to within about 100 mV to 500 mV of either rail or better.

In this circuit, we end up testing both limits. The output of the first op-amp stage (U2A) should go very near common — the output negative or lower rail — because any voltage present at the output of U2A at zero wind is further amplified by U2B or multiplied by about four — the gain of the second stage amplifier. For example, if the input to the U2B second stage (at U2B pin 3) is 0.6 V, the minimally achievable second stage output is 4 x 0.6V or 2.4V, a typical zero wind value with op-amps I have used. Notice that I am also pushing the available input range, by requiring that the second stage op-amp still operate with an input very near to the lower rail.

Some op-amps can operate closer to the rails than specified in the data sheets, especially with light loading. I have used the TI OPA2277 and the Analog Devices OP-297 with good success, but it should be noted that at either end of the scale I am violating the specifications for these op-amps. The TI OPA2277 and the Analog Devices OP-297 are extremely precise op-amps when used as intended, but these op-amps are not rated to maintain closed loop (op-amp) performance very near to either rail. This violation will not damage or reduce the life to the op-amp, but it does mean that at the lower end of the scale (very near a zero wind set point of 2.5V), there will be a small range of non-linear operation and then a dead zone where the op-amp saturates to a small value near common.

As mentioned in the article, the National Semiconductor LM6132BIN gives exceptionally good performance to both rails and is rated for both input and output rail-to-rail operation. This op-amp can operate almost all the way to common (the lower rail). The input (common mode) voltage range is all the way to both rails, and the output swing is to within better than about 200 mV of either rail, typically better than 100 mV with operation between 15V and common. Using an LM6132BIN, the zero wind value can be set as low as about 0.1V at the output of U2A, giving a zero wind output below 0.5V. There are many other rail-to-rail op-amps available today, but few that can operate on a 15V power supply (the relatively high 15V rail voltage is needed to power the LM399 oven).

PARTS LIST

(Listed are the parts in the Geller Labs kit; most recommended parts can be substituted with any same-valued part from your junk box.)

ITEM	QTY	REFERENCE	VALUE	DESCRIPTION
❑ 1	2	C1,4	0.1µF	Ceramic, CKO6, 10%, 100V, or equivalent Mouser CK06BX104K
❑ 2	2	C2,3	0.1µF	Panasonic film, ECQ-V1H104JL Digi-Key P4525-ND, or equivalent
❑ 3	1	U1	LM399H	7V ovenized reference diode, National Semiconductor Digi-Key LM399H-ND
❑ 4	1	U2	LM6132BIN	National Semiconductor, Digi-Key LM6132BIN-ND
❑ 5	1	R1	100	1% metal film, 1/2W (Mouser)
❑ 6	1	R5	10K	1% metal film, Xicon 1/4W (Mouser)
❑ 7	1	R2	3.24K	1% metal film, Xicon 1/4W (Mouser)
❑ 8	2	R3, 4, 6	7.5K	1% metal film, Xicon 1/4W (Mouser) For ex: Mouser ME271-7.5K
❑ 9	1	R7	5K	Bourns 3329H trimpot Mouser 652-3329H-1-502
❑ 10	1	R8	4.64K	1% metal film, Xicon 1/4W (Mouser)
❑ 11	1	IC socket		Mill-Max DIP Low Profile Mouser: 575-193308
❑ 12	1	PCB		Geller Labs **www.gellerlabs.com** MGTA PCB

Kit of all parts (no documentation, no enclosure) — Geller Labs MGTA KIT (go to website)

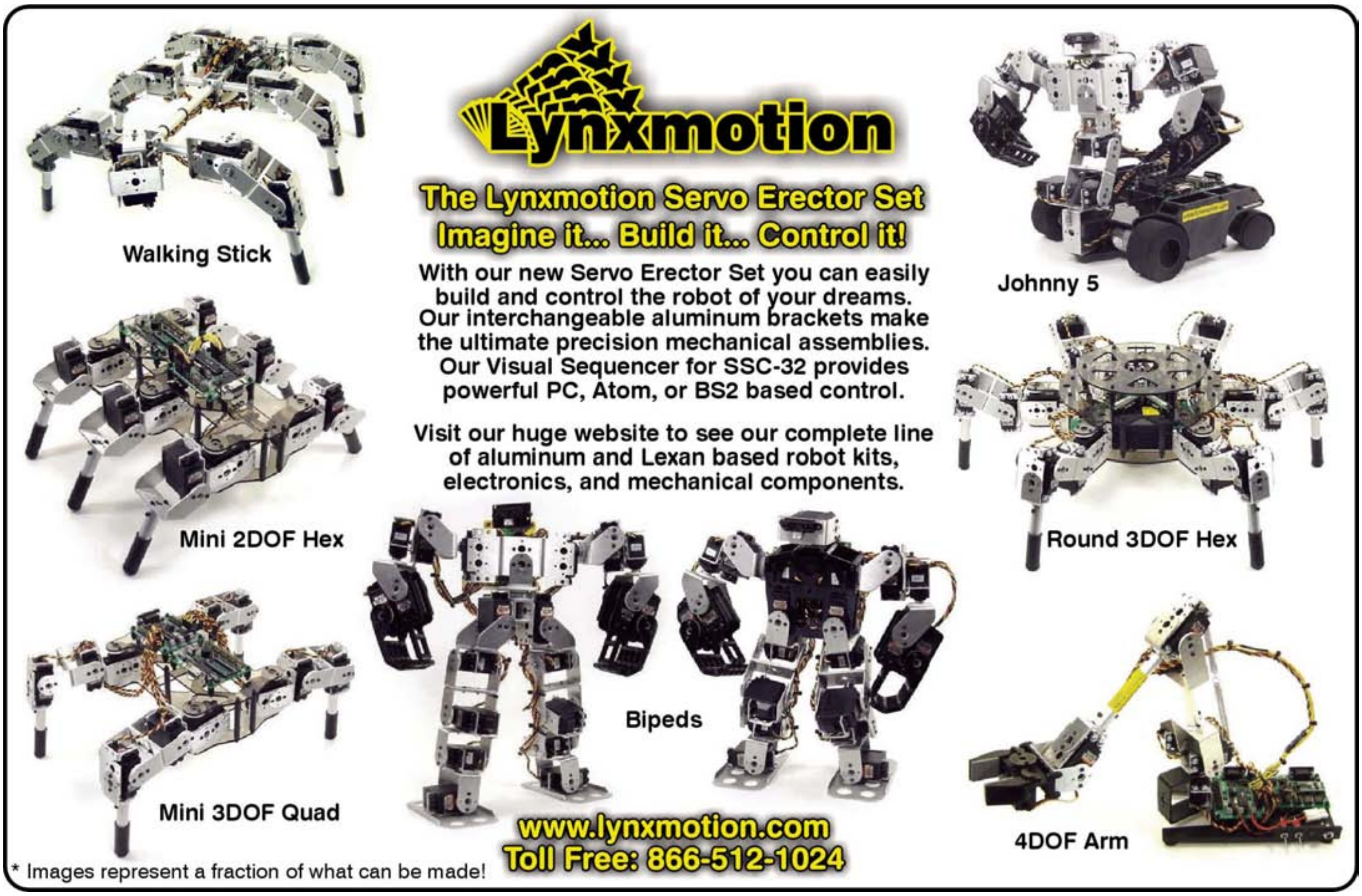
ranging from near 0.2V to 14V full scale. For a TI OPA2277 or an Analog Devices OP-297 dual op-amp, the range is about 2.5V to 13V. See the sidebar for more information on op-amp rail-to-rail performance. Note that C5 is available for especially noisy environments. It can be an additional ceramic capacitor or a tantalum or electrolytic capacitor (observe polarity!). Best operation is achieved with a 15V linear power supply, but a switcher should be okay too if C5 is installed.

Ideas for Future Expansion

The applications sidebar shows some ideas for different uses. Many experiments can be done to further characterize the project. For example, measure how changes in absolute temperature change the output voltage independent of the wind. Or, you can calibrate the board against known air speeds to determine an absolute calibration or the linearity of the output over a range of low velocity wind speeds. A small muffin fan can be used at different voltages to create variable breezes for calibration experiments. Some fans create a lower, less concentrated breeze on the intake side. Another factor to investigate is how the LM399 oven currents vary with time and to determine if LM399 oven life is reduced by running it at elevated heater currents for long periods of time in a continuous breeze.

As a closing note, I need to mention that I filed a patent application regarding the use of ovenized reference diodes as sensors in thermal anemometers. If a patent issues, I will grant free licenses to individuals for use in hobby and amateur science experiments (but not for commercial use or sales including multiple hobby sales).

Enjoy! Please feel free to let us know how you are using your MGTA. More information can also be found at www.gellerlabs.com **NV**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NOTE: Surplus Sales is not responsible for its use or misuse. Power Supply is completely open and user is subject to dangerous voltages.
$119 each - $108 (3+)
VU Meter -20 to +3 dB Scale
(MTR) VU-2X3
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• Dimensions: 2-3/8" x 3-1/4" x 9/16" high
Made in Korea. Very Nice!!
$25 each - $22 (5+)
Air Conditioning Contactor Relay
(KO) 3ARR8-MARS4
General Electric air conditioning contactor relay.
2PST, 30 amp, 240v contacts, LRA 125 amps, 24 vac coil.
Dimensions: 2-3/4" square x 2-1/2" high.
ONLY $15 each
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Fingerstock: Over 20 styles and sizes
HI Manuals: 1,000s of radio, military and test equipment manuals on hand!!
Fujitsu Pen Computers
Motors & Pumps: Synchronous, gear reduction, projector motors, etc.
Transformers: High & low voltage, chokes.
Pressure Switches & Transducers
Vacuum Tubes: Over 1,000,000 vacuum tubes in stock!!
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Coaxial Relays: Many power levels HF to Microwave.
Potentiometers: Wire wound and carbon, shafted and screwdriver adjust.
High Impact Shipping Containers
1218 Nicholas Street, Omaha, NE 68102 • Fax: 402-346-2939 • e-mail: grinnell @ surplussales.com • Visa, Mastercard, American Express or Discover
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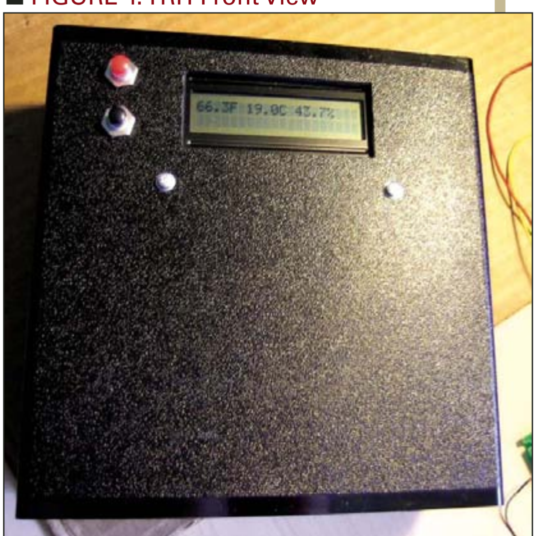
Using a 16F870 PIC, a two-Line LCD display, and two Sensirion SHT15 temperature/humidity sensors, you can build this handy, portable, battery-powered device which will give you easy, accurate simultaneous temperature and relative humidity readings inside your house and outside your window.

MONITOR INDOOR/OUTDOOR TEMPERATURE AND RELATIVE HUMIDITY WITH ONE DEVICE

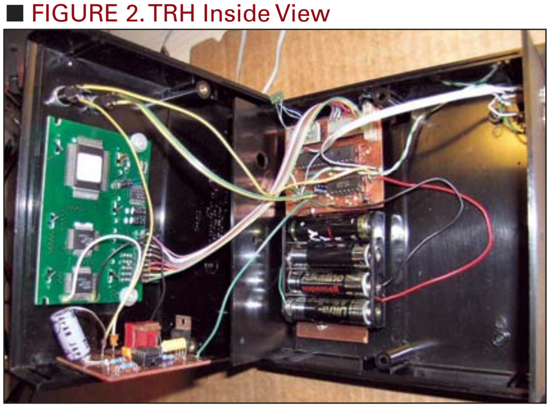
The LCD also features a backlit display using an electro-luminescent strip, which enables you to read the display even if the room is dark. The remote sensor is connected to the monitor via two jack plugs allowing the monitor to be used even if no outside sensor is used. This also allows easy changes of location of the remote sensor. Figure 1 shows the display and control side of the monitor, while Figure 2 shows the inside view.

I chose the 16F870 PIC because it is inexpensive, has 2 x 8 line ports, 1 x 5 line port, 2K of program memory, and analog input capabilities (not necessary for this project, but handy for interfacing the LM34Z temperature sensor). The PIC is programmed to talk to the two sensors and display their information on the LCD. This entire article — including the programming — was inspired by a previous *Nuts & Volts* article, Environmental Sensing by Jon Williams, November 2002. Jon wrote his article for the BASIC Stamp, but I was able to use much of his SHT15 communications programming within the Microcode Studio Plus program and the PICBasic Pro Compiler Ver. 2.45. I added the LCD display into the program along with some code to detect if the remote sensor is plugged in. Since there is no critical timing involved, the PIC uses an RC circuit for the timing. Using a crystal is much more expensive. The math in the program is compliments of Tracy Allen of EME Systems (**www.emesystems.com**). I added math statements to com-

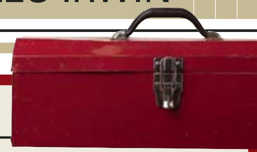
■ FIGURE 1. TRH Front View



■ FIGURE 2. TRH Inside View



BY CHARLES IRWIN

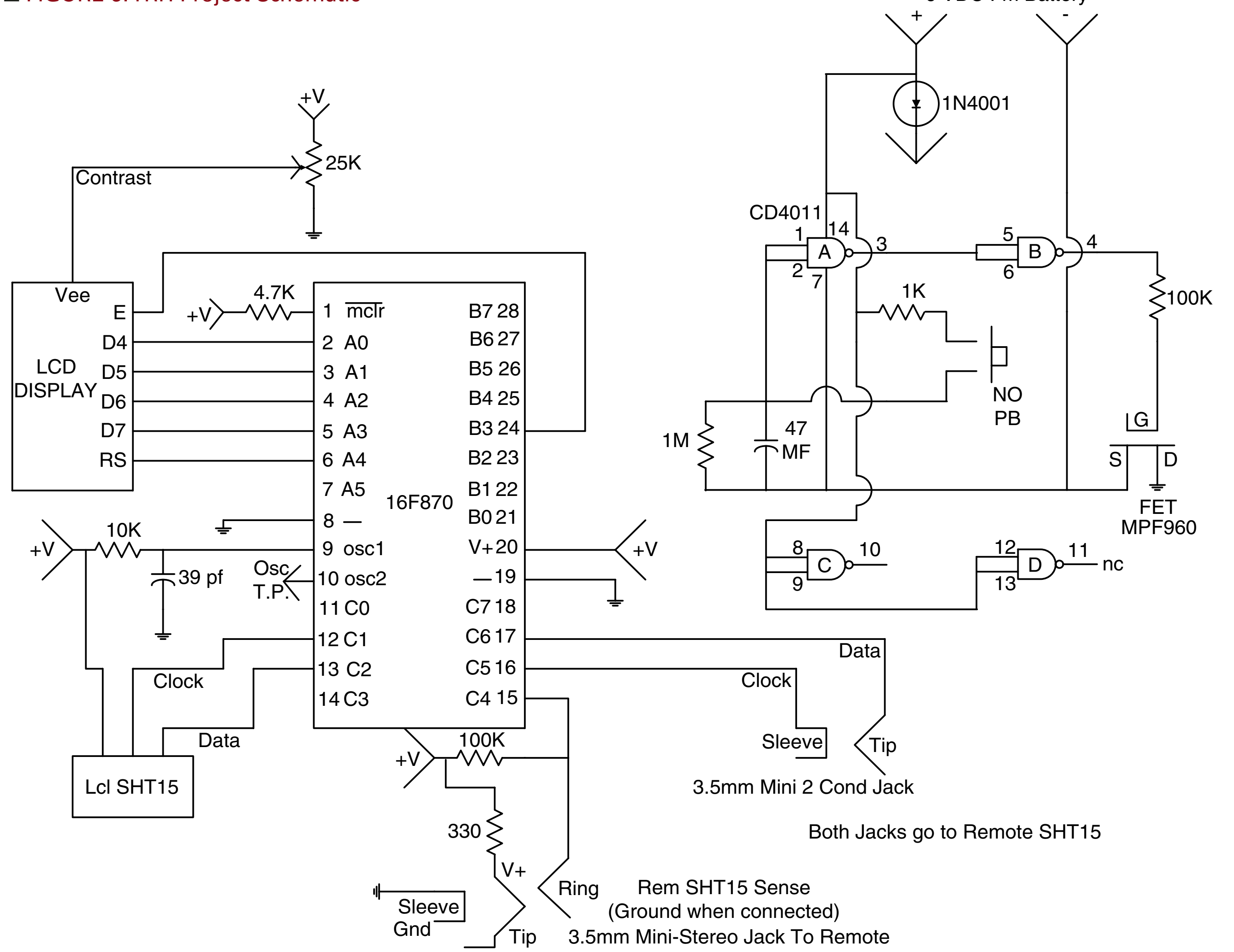


pensate for the PIC's inability to deal with negative numbers. The PIC must be programmed with the code "TRHNegNr.hex" within "TRHProj.zip" available from the *Nuts & Volts* website. The zipped file also contains all of the figures mentioned in this article, all of the files generated by the PIC Compiler (suitable for use and modification by the MPLAB IDE program available from www.microchip.com for free), and also a BASIC Stamp II version of the program; i.e., a BASIC Stamp II could be used instead of the 16F870 PIC. Check the file "TRHProj.bs2" for the connections between the BS2 chip and the SHT15s, LCD display, and jack plugs.

LCD EL DRIVER PARTS LIST

RESISTORS	SUPPLIER	PART NO.	PRICE
❑ 47K	Digi-Key	47KEBK-ND	Pkg of 5 at $.28 each
❑ 10K	Digi-Key	10KEBK-ND	Pkg of 5 at $.28 each
❑ 8.2K	Digi-Key	8.2KEBK-ND	Pkg of 5 at $.26 each
CAPACITORS			
❑ .01µF disc	Digi-Key	445-1260-1-ND	Pkg of 10 at $.50 ea
❑ .1µF disc	Digi-Key	445-1325-1-ND	Pkg of 10 at $.57 ea
SEMICONDUCTORS			
❑ 555 timer	Digi-Key	296-1411-ND	$.45
❑ MPF960 FET N-channel or equivalent	Digi-Key	MPF960OS-ND	$.81
❑ 1N914 diode	Digi-Key	1N914CT-ND	$.09
MISCELLANEOUS			
❑ Audio transformer 1K center tap primary/ 8Ω secondary	RadioShack	273-1380	$2.49
❑ N.O. push button switch	Digi-Key	506PB-ND	$.86

■ FIGURE 5. TRH Project Schematic



Parts and Construction

See the Parts List for a detailed description of each part, where it can be obtained, and how much it costs.

Most parts are available from Digi-Key (**www.digikey.com**). Some others are available from RadioShack. The LCD display is available from B and G Micro (**www.bgmicro.com**) for $4.95, part #LCD1022. The temperature/humidity sensor is available from Onset Computer, Inc., for $19.17 each. Contact Onset by phone at 508-759-9500, mail at P.O. Box 3450, Pocasset, MA 02559-3450, or email at **sales@onsetcomp.com** They also have a website at **www.onsetcomp.com** but the SHT15 is not available there. Figure 3 gives a view of the etched side of the PC board, while Figure 4 shows the component side of the board with an "x-ray" view (Figures 3 and 4 are available on the *Nuts & Volts* website at **www.nutsvolts.com**). Figure 5 is a schematic of the monitor while Figure 6 is a schematic of the LCD backlight driver (EL driver).

The construction of the monitor PC board is quite simple, however the entire unit including the LCD backlight driver could easily be done on the RadioShack pre-drilled, solder-ringed holes, PC Board using point-to-point wiring. The LCD backlight driver should not be operated unless it is connected to the LCD. The voltages from the driver can easily exceed 600 volts with no load. When connected to the LCD, this voltage drops to about 100 volts.

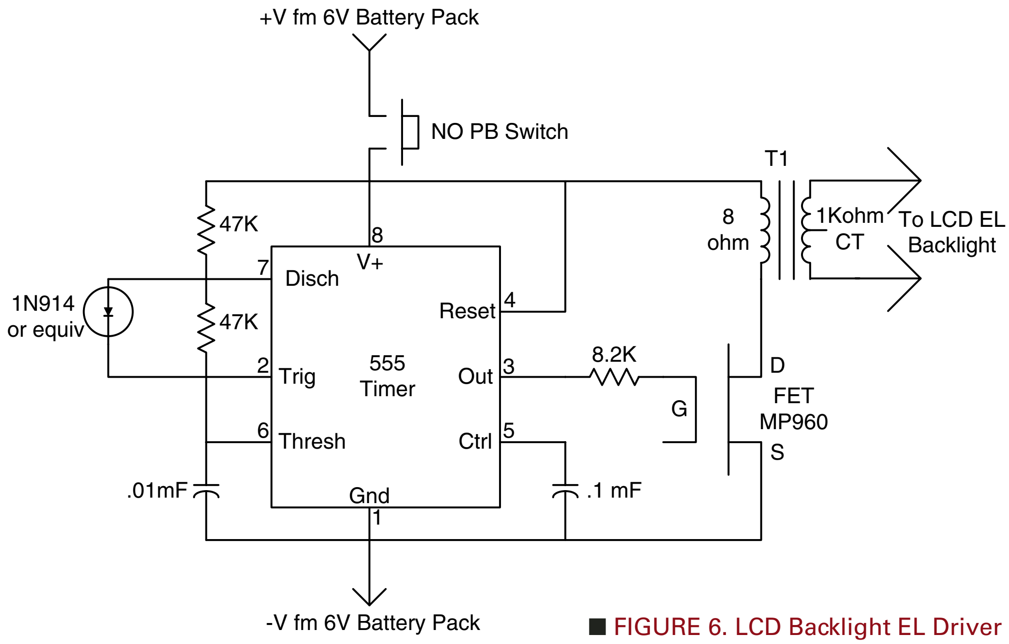
INDOOR/OUTDOOR TEMPERTAURE & RELATIVE HUMIDITY PARTS LIST

RESISTORS	SUPPLIER	PART NO.	PRICE
❑ 4.7K	Digi-Key	4.7KEBK-ND	Pkg of 5 at $.28 each
❑ 100K	Digi-Key	100KEBK-ND	Pkg of 5 at $.28 each
❑ 1M	Digi-Key	1MEBK-ND	Pkg of 5 at $.28 each
❑ 100K	Digi-Key	100KEBK-ND	Pkg of 5 at $.28 each
❑ 330	Digi-Key	330EBK-ND	Pkg of 5 at $.28 each
❑ 1K	Digi-Key	1KEBK-ND	Pkg of 5 at $.28 each
❑ 10K	Digi-Key	10KEBK-ND	Pkg of 5 at $.28 each
❑ 25K ohm trimpot	Digi-Key	3006P-253-ND	$1.73
CAPACITORS			
❑ 47 µF, Electrolytic	Digi-Key	493-1039-ND	$.24
❑ 39 pf disc	Digi-Key	1333PH-ND	Pkg of 10 $.60
SEMICONDUCTORS			
❑ CD4011 Quad Two Input NAND Gate	Digi-Key	CD4011BCN-ND 14 Pin DIP	$.50
❑ 16F870 PIC	Digi-Key	16F870-I/SP-ND 28 Pin DIP	$4.63
❑ MPF960 FET N-Channel or Equivalent	Digi-Key	MPF960OS-ND	$.81
❑ 1N4001 Diode	Digi-Key	1N4001DICT-ND	Pkg of 10 at $1.36
MISCELLANEOUS			
❑ Wire Jumper			
❑ 2 Row, 16 Char/Row LCD, 4 Data Lines, Using HD (Hitachi) 44780 Controller or Equivalent, EL Backlight optional For connection/programming details, click on "Technical Information" at the website.	www.bgmicro.com	LCD1022	$4.95
❑ Normally Open Momentary Push Button Switch	Digi-Key	506PB-ND	$.86
❑ 14 Pin DIP Socket (for CD4011)	Digi-Key	ED58143-ND	$1.05
❑ 28 Pin DIP Socket (for 16F870)	Digi-Key	ED58283-ND	$2.02
❑ Plastic Project Box	RadioShack (in various sizes)		approx. $7.00
❑ Single Sided Copper Clad PC Board, 3"x 4"	Digi-Key/RadioShack	PC9-N9/RS276-1499	$3.13/$3.79
❑ Battery Holder for 4 x AA cells	Digi-Key/RadioShack	2478-ND/RS270-391	$1.15/$1.69
❑ 3.5mm (1/8") Mini Stereo Jack 3 Conductor (Female)	RadioShack	RS274-249	2 at $1.49
❑ 3.5mm (1/8") Mini Stereo Jack 3 Conductor (Male)	RadioShack	RS274-1547	2 at $2.29
❑ 3.5mm (1/8") Mini Audio Jack 2 Conductor (Female)	RadioShack	RS274-248	2 at $1.99
❑ 3.5mm (1/8") Mini Audio Jack 2 Conductor (Male)	RadioShack	RS274-286	2 at $1.99
❑ PC Board (if used in lieu of Copper Clad PC Board) 4-1/2" x 6-5/8"	RadioShack	RS276-147	$3.99
❑ SHT15 Temperature/Humidity Sensor	Onset Computer (see text for details)		$19.17 ea

Author Bio

■ *Charles Irwin is a retired engineer and has worked for ITT Worldcommunications, AT&T, and Western Union over a period of 30 years. He holds an Extra Class Ham Radio License (NO2K) and has been licensed since 1974, receiving his first Amateur Radio License from the German Bundespost (DJ0HZ). Irwin has been home-brewing electronic projects since he was 12 years old. He may be contacted at chuck irwin43@netzero.net*

If you would like to send your PIC to Charles and have him program it for you, email him for further information.



■ FIGURE 6. LCD Backlight EL Driver

Using the Monitor

The monitor is simple to use. Pressing the push button activates the unit for approximately one minute and then shuts off automatically. The current drain while the unit is displaying information is about 6 miliamps. When the unit is off, the only current drain is from the CD4011 quad Nand gate, and that was so low I could not even measure it (less than 0.1 microamp).

The batteries should last as long as their normal shelf life provided the LCD backlight is not used continuously. It draws approximately 100 miliamps. It is quite easy to read the display in normal light; the backlight is only necessary in the dark. The display on the LCD is as follows:

71.6F 22.0C 58.5%
059.7F 15.4C 76.3%

The top row indicates conditions from the monitor's internal SHT15 sensor and the bottom row indicates conditions from the monitor's remote SHT15 sensor. The bottom row incorporates an extra digit for the F display, since outside temperatures may go over 100 degrees.

The bottom row will also show negative temperatures, both Centigrade and Farenheit. When the remote sensor is unplugged, there is no second line display.

I would appreciate any suggestions or comments from the *Nuts & Volts* readers. I can be reached at NO2K@arrl.net **NV**

NEW PRODUCTS

HARDWARE
SOFTWARE
GADGETS
TOOLS

WIRELESS FIELD STRENGTH TESTER

Alan Broadband Co. now offers a 1 MHz to 8 GHz Wireless Field Strength Tester, model ZC300. This hand-held device uses active wireless ICs (instead of diodes) for amplification and detection, attaining a higher sensitivity and bandwidth for field strength measurements. Sensitivity is -70 dBm @ 2.4 GHz and higher at lower frequencies.

The ZC300 has both fixed internal antennas and coaxially connected antennas to detect and locate RFI sources and cable leaks, as well as mW hidden Fox transmitters. It is ideal for wireless installations; far field tuning-up of transmitters and antennas, plotting antenna fields in dB, and measuring antenna front/back ratios. It helps to align distant antennas and locate sources of undesirable oscillations. The ZC300 is complete with a directional 1.8-6.4 GHz Log Periodic antenna for $599.

For more information, contact:
Alan Broadband Co.
Web: **www.zapchecker.com**

THE *ezDISPLAY*

Multilabs has announced the release of the ezDISPLAY. The ezDISPLAY is a serial LCD graphics module with an integral touchscreen. The LCD has a resolution of 160 by 80 pixels and can display both graphics and text. The touchscreen is a resistive type screen such as the types used on PDAs and the like. This allows the ezDISPLAY to track the position of the touchscreen down to the pixel. The integral controller breaks down the complex decoding operation of the touchscreen and returns a simple X and Y position for ease of operation.

The ezDISPLAY is controlled through an asynchronous communication protocol that allows an external control to draw images and retrieve information. Both graphic and text commands are provided to allow for a wide range of applications. Some of the serial commands that control the ezDISPLAY are: Add Character, Character Placement, Download Screen, Erase Area/Screen, Get Touchscreen Data, Draw Line (Straight), Pixel, Retrieve Screen, Save Screen, and Touchscreen Calibration.

The ezDISPLAY comes with a complete built-in ASCII character set that is user replaceable and a generous amount of memory to create 32 user-defined characters. All user-defined characters are stored in non-volatile memory so they are not lost when power is removed.

Memory is also provided to store up to four screens that can be re-loaded at any time. Again, these saved screens are stored in non-volatile memory. Characters and graphics can be intermixed on the screen and characters can be placed in landscape or portrait mode along with many other options. The ezDISPLAY is also a true bitmap in that there are no character cells. This allows character placement to occur anywhere on the screen.

The ezDISPLAY even has a command that allows downloads of screens from other sources such as those drawn on a computer. Screens can be pre-drawn on a computer, downloaded to the ezDISPLAY, saved in memory, and then recalled when needed in the end-use application.

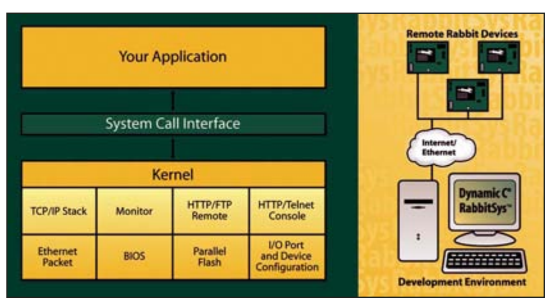
The ezDISPLAY comes with a floating character that makes a great companion to the touchscreen. The floating character can be displayed and moved around anywhere on the screen without destroying any of the image on the LCD. This adds another level of character display to the ezDISPLAY. The floating character can either be controlled by the end-user controller or it can be "latched" to the touchscreen so it automatically follows the movement of the user stylus or finger.

The ezDISPLAY comes with four mounting holes for secure placement in any product and a four-pin SIP header is used to supply power and access the serial data lines.

For more information, contact:
Multilabs
Tel/Fax: **949-458-7625**
Web: **www.multilabs.net**

RABBITSYS™ SOFTWARE FOR REMOTE MANAGEMENT OF EMBEDDED DEVICES

Rabbit Semiconductor, Inc., has released RabbitSys, an operating system that delivers program reliability for Ethernet-enabled, embedded



applications. System reliability often overshadows the goals of any embedded project. The RabbitSys kernel available now pre-loaded on the powerful RCM3365 RabbitSys core module, provides embedded systems designers the ability to update, monitor, configure, detect, diagnose, and even debug embedded systems from remote locations.

RabbitSys increases reliability by providing extensive feedback during development and debugging cycles. RabbitSys safeguards access to embedded system resources, like I/O and system memory, assuring software integrity.

RabbitSys is easy to use and helps system integrators save time and money. Those who already work with Dynamic C® will find RabbitSys easy to work with using the RCM3365 RabbitSys core module. Features such as the program monitor, the event handler, and safe system shutdown cradle the user's application and make it resistant to external transient errors. RabbitSys creates a solid foundation and increases system reliability for Rabbit-based embedded systems programmed with Dynamic C.

Assurance of reliability extends beyond the confines of the development environment. The remote capabilities of RabbitSys enable embedded programmers to raise email alerts when a software failure occurs. During such failures, RabbitSys takes the necessary steps to return attached equipment to its default state. RabbitSys removes the burden and expense of sending out a technician. Instead, a simple network connection and software update to the malfunctioning device repairs the problem. RabbitSys also scales with the deployment of new devices, allowing users to manage many devices concurrently.

A RabbitSys Development Kit includes everything needed to get an application running quickly and easily. The kit comes complete with a RabbitSys ready RCM3365 RabbitCore module, a prototyping board, Dynamic C development software, RabbitSys CD with samples, and documentation. The development kit sells at $409 and a standalone RabbitSys enabled RCM3365 core module sells for (qty. 10/100) $113/96. RabbitSys standalone software sells for $299/CD, and $289/Download. RabbitSys software today works with the RabbitSys enabled RCM3365 core module and in the future will be supported on additional RabbitCore modules.

For more information, contact:
Rabbit Semiconductor
Tel: **530-757-8400**
Fax: **530-757-8402**
Web: **www.rabbitsemiconductor.com**

LED PLANT LIGHT BARS FOR PLANT GROWTH

How do plants capture and use light? This question has been studied and researched for decades, and researchers have long known that plants use different frequencies of light, or different colors of light, for different purposes. Some colors of light make plants grow and bloom, while others promote compact growth, and some aren't really used much at all. For example, the leaves of plants look green because they reflect green light. If a plant reflects a color of light instead of absorbing it, that color isn't used to help a plant grow.

Scientists used this knowledge to develop lamps that would let them raise plants without sunlight. Their new "grow lights" weren't developed from scratch. They took existing lamps — the same ones used to light our homes and factories — and modified them to produce more of the colors of light that are used efficiently for plant growth and they were successful.

There are many lamps that can be used to help grow plants without sunlight, however, they produce a lot of light that plants can't use efficiently.

LEDtronics now offers PlantLED grow lights which are designed from the ground up, optimized for plant growth, not human vision. Using light emitting diodes, or LEDs, they select the colors of light plants use most efficiently for vigorous growth and health. The result is a plant grow light that uses very little energy yet provides all the light plants need to thrive indoors. LEDtronics has used their specialized knowledge of LEDs to make sure each bulb operates optimally, providing maximum light output and maximum bulb life.

Their patent pending technology offers advantages over conventional artificial plant grow lighting, such as:

Low Energy Use: LEDs are more efficient at producing light than conventional glass-envelope bulbs. Depending on configuration, a typical LED-PlantBar uses less than two watts of power, an important fact as energy costs continue to rise.

Targeted Light Output: Unlike "broad spectrum" plant grow lights, which produce a lot of light plants can't use efficiently, PlantLED products only deliver the light colors plants want most for vigorous, healthy growth.

No "White Light" Glare: Other plant grow lights use technologies generally used to light rooms and buildings, which makes them very bright to the human eye. PlantLED products deliver light that is very bright to plants, but relatively dim to people. Plants get what they need without the "white light" glare.

For more information, contact:
LEDtronics, Inc.
23105 Kashiwa Ct.
Torrance, CA 90505
Tel: **800-579-4875**
Fax: **310-534-1424**
Web: **www.ledtronics.com**

MAINS-POWERED STEREO RIAA PHONO PREAMP

TDL® Technology, Inc., has announced their Model 409, Main-Powered Stereo RIAA Phono Preamp especially designed to drive a sounds card's line-input for restoring 33-1/3 RPM records which were recorded using standard RIAA equalization. The preamp uses low-noise op-amps and a cast aluminum enclosure for very low output noise and very low power line hum pickup. Although the 409 is mains-powered, its noise and hum levels are essentially the same as their model 403 battery-powered stereo RIAA phono preamp.

Single quantity price is $202 USD plus shipping. Availability is stock to four weeks. A full data sheet and User Guide in PDF format can be downloaded from the TDL Technology website.

For more information, contact:
TDL Technology, Inc.
5260 Cochise Trl.
Las Cruces, NM 88012
Tel: **505-382-3173**
Fax: **505-382-8810**
Web: **www.tdl-tech.com**

REB FLUSH MOUNT PLUG ADAPTOR

The invention of the REB Flush Mount Plug Adaptor offers a new concept to abut a power cable with a flush fit against a wall, rather than having it extend outward from the wall, as is most common. This product adapts standard direct insert power cords into flush mount inserts by simple plugging the cord into the REB, which then flush mount into the receptacle.

Very simple in design and use, the REB Adaptor immediately eliminates the problems associated with cables that extend outward from a power receptacle or standard power adaptor plugs.

The 45 degree angle of the female receptacle is more effective at holding the cord in place without pulling. This product is compatible with all standard electrical cords and outlets.

The REB Flush Mount Plug Adaptor prevents hazards associated with compacted or ill fitting connections, including bent prongs, frayed wiring, and the possibility of electrical fires.

For more information, contact:
Advent Product Development, Inc.
313 Commerce Dr.
Pawleys Island, SC 29585
Tel: **843-237-5915**
Fax: **843-237-0291**
Web: **www.adventproduct.net/19117/default.htm**

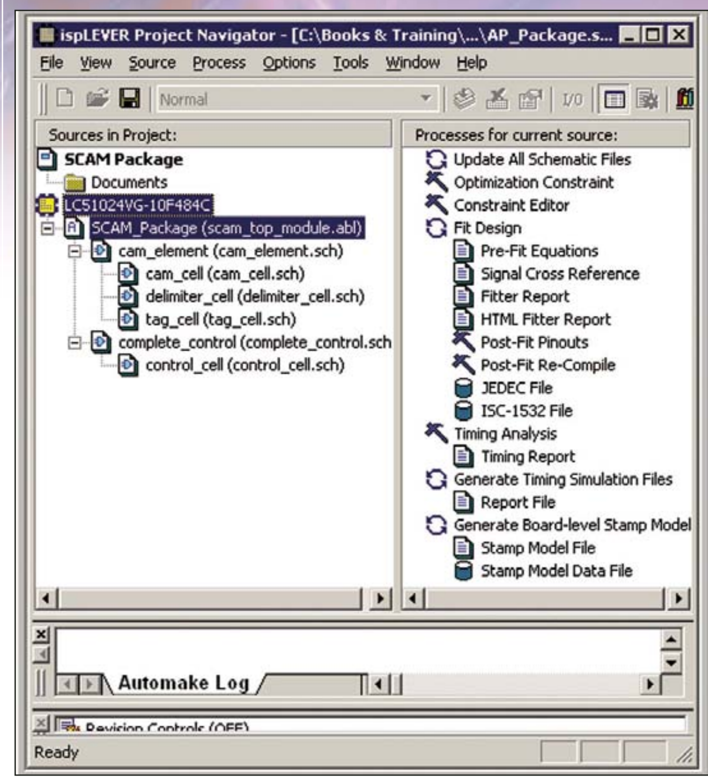
ELECTRONET

>>>> go to www.nutsvolts.com — click Electro-Net <<<<

DATA Processing Using SCAM(5)

In this article, I describe how to assemble the SCAM basic cell types, which I developed using ispLEVER Schematic Editor, into a full-fledged package using ABEL hardware description language and the ispLEVER Project Navigator.

IMPLEMENTING SCAM: Assembling the Parts With ABEL



■ FIGURE 1. The SCAM Design Hierarchy in ispLEVER Project Navigator.

WHAT IS ABEL?

ABEL (Advanced Boolean Equation Language) is a means of making behavior-like descriptions of a logic circuit. ABEL is an industry standard hardware description language (HDL) that was developed by Data I/O Corporation for programmable logic devices (PLD). There are other hardware description languages, such as VHDL and Verilog. ABEL is a simpler language than VHDL that is capable of describing systems of larger complexity.

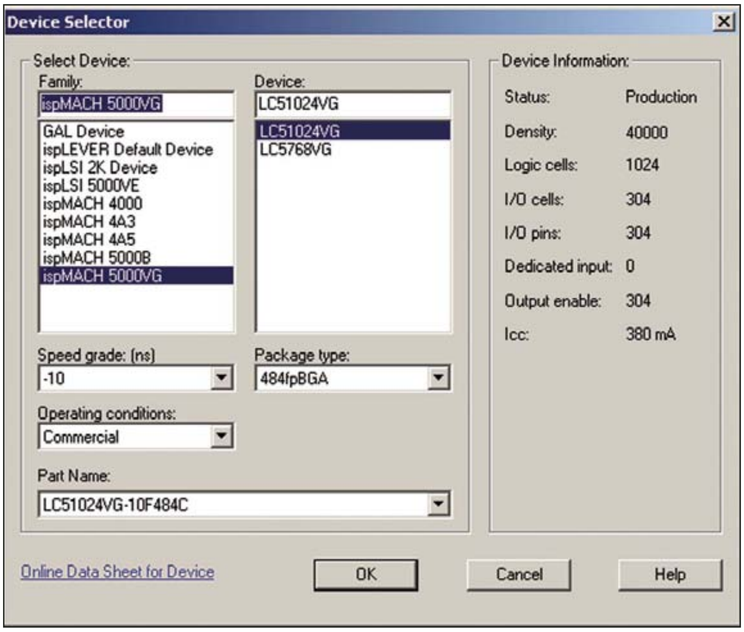
ABEL can be used to describe the behavior of a system in a variety of forms, including logic equations, truth tables, and state diagrams, using C-like statements. The ABEL compiler allows designs to be simulated and implemented into PLDs such as PALs, CPLDs, and FPGAs.

An ABEL source file consists of the following elements:

- Header, including Module,

By Gamal Ali Labib

■ FIGURE 2. Selecting the FPGA device for the SCAM implementation in ispLEVER Project Navigator.



Options, and Title.

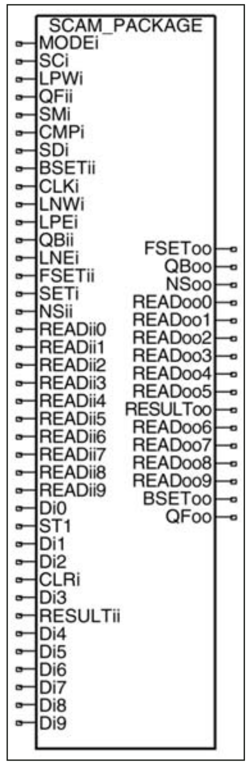
• Declarations, including Pin, Constant, Node, Sets, States, and Library.

• Logic Descriptions, including Equations, Truth-table, and State_diagram.

• Test Vectors: Test_vectors.

• End.

As we will see, most of those ABEL elements are used in describing the top level of the SCAM package.



■ FIGURE 3. SCAM Package Symbol generated by ispLEVER Project Navigator.

THE ABEL TOP MODULE

The top of the SCAM design hierarchy is an ABEL module (see Listing 1) in which I replicate the building block of the SCAM, namely the CAM word. The ABEL module appears in the ispLEVER Project Navigator window of Figure 1, superseding the schematic modules of the building blocks of the SCAM. The ABEL module starts with a declaration of the next

■ LISTING 1. ABEL Top Module of SCAM Package.

LISTING 1

```
MODULE SCAM_Package

TITLE 'SCAM Block Package ABL'

DECLARATIONS
cam_element      INTERFACE
    (clr,clk,ST,SET,SD,RESULTi,READi_9_,READi_8_,READi_7_,READi_6_,READi_5_,READi_4_,READi_3_,READi_2_,READi_1_,READi_0
    _,QFi,QBi,NSi,MODE,LPW,LPE,LNW,LNE,FSETi,D_9_,D_8_,D_7_,D_6_,D_5_,D_4_,D_3_,D_2_,D_1_,D_0_,Cn_9_,Cn_8_,Cn_7_,Cn_6_,
    Cn_5_,Cn_4_,Cn_3_,Cn_2_,Cn_1_,Cn_0_,C_9_,C_8_,C_7_,C_6_,C_5_,C_4_,C_3_,C_2_,C_1_,C_0_,BSETi          ->
    RESULTo,READo_9_,READo_8_,READo_7_,READo_6_,READo_5_,READo_4_,READo_3_,READo_2_,READo_1_,READo_0_,QFo,QBo,
    NSo,FSETo,BSETo);
complete_control    INTERFACE
    (clr,clk,SM,SC,READi_9_,READi_8_,READi_7_,READi_6_,READi_5_,READi_4_,READi_3_,READi_2_,READi_1_,READi_0_,Di_9_,Di_8
    _,Di_7_,Di_6_,Di_5_,Di_4_,Di_3_,Di_2_,Di_1_,Di_0_,CMP      ->
    READo_9_,READo_8_,READo_7_,READo_6_,READo_5_,READo_4_,READo_3_,READo_2_,READo_1_,READo_0_,Cn_9_,Cn_8_,Cn_7
    _,Cn_6_,Cn_5_,Cn_4_,Cn_3_,Cn_2_,Cn_1_,Cn_0_,C_9_,C_8_,C_7_,C_6_,C_5_,C_4_,C_3_,C_2_,C_1_,C_0_);
CE macro (x)
{ @expr {CE}?x; };
"declare 1024 associative words in the SCAM
@const rep = 1024;
@const x = 1;
@repeat rep
{ CE(x-1) FUNCTIONAL_BLOCK cam_element;
@const x = x + 1; };
CC          FUNCTIONAL_BLOCK complete_control;
"input pins of first element
CLKi, CLRi          PIN;
SMi, SCi, SDi, STi  PIN;
LNEi, LNWi          PIN;
LPEi, LPWi          PIN;
MODEi, SETi, CMPi        PIN;
FSETii              PIN;
```

Listing 1 *continued*

```
BSETii              PIN;
NSii                PIN;
QBii                PIN;
QFii                PIN;
RESULTii            PIN;
Di9..Di0            PIN;
READii9..READii0         PIN;

"output pins of last element
BSEToo              PIN;
FSEToo              PIN;
NSoo                PIN;
QBoo                PIN;
QFoo                PIN;
RESULToo            PIN;
READoo9..READoo0         PIN;
"sets
Di = [Di9..Di0];
READii = [READii9..READii0];
READoo = [READoo9..READoo0];
INP1 = [CLKi,CLRi,SDi,STi,LNEi,LNWi,LPEi,LPWi,MODEi,SETi];          "set of common input signals to all cam symbols
INP2 = [CLKi,CLRi,SMi,SCi,CMPi];                                    "set of common input signals to control symbols
EQUATIONS
"output pins of SCAM
BSEToo = CE(rep-1).BSETo;
FSEToo = CE(rep-1).FSETo;
NSoo = CE(rep-1).NSo;
QBoo = CE(rep-1).QBo;
QFoo = CE(rep-1).QFo;
RESULToo = CE(rep-1).RESULTo;
READoo =
        CE(rep-1).[READo_9_,READo_8_,READo_7_,READo_6_,READo_5_,READo_4_,READo_3_,READo_2_,READo_1_,READo_0_];
"input pins of SCAM
CC.[READi_9_,READi_8_,READi_7_,READi_6_,READi_5_,READi_4_,READi_3_,READi_2_,READi_1_,READi_0_] = READii;
CC.[Di_9_,Di_8_,Di_7_,Di_6_,Di_5_,Di_4_,Di_3_,Di_2_,Di_1_,Di_0_] = Di;
CC.[clr,clk,SM,SC,CMP] = INP2;
CE(0).[READi_9_,READi_8_,READi_7_,READi_6_,READi_5_,READi_4_,READi_3_,READi_2_,READi_1_,READi_0_]=
        CC.[READo_9_,READo_8_,READo_7_,READo_6_,READo_5_,READo_4_,READo_3_,READo_2_,READo_1_,READo_0_];
CE(0).BSETi = BSETii;
CE(0).FSETi = FSETii;
CE(0).NSi = NSii;
CE(0).QBi = QBii;
E(0).QFi = QFii;
CE(0).RESULTi = RESULTii;
"internal connections common to all associative words in the SCAM
@const x = 1;
@repeat rep
{ "common connections
CE(x-1).[clk,clr,SD,ST,LNE,LNW,LPE,LPW,MODE,SET] = INP1;
CE(x-1).[Cn_9_,Cn_8_,Cn_7_,Cn_6_,Cn_5_,Cn_4_,Cn_3_,Cn_2_,Cn_1_,Cn_0_]=
        CC.[Cn_9_,Cn_8_,Cn_7_,Cn_6_,Cn_5_,Cn_4_,Cn_3_,Cn_2_,Cn_1_,Cn_0_];
CE(x-1).[C_9_,C_8_,C_7_,C_6_,C_5_,C_4_,C_3_,C_2_,C_1_,C_0_]= CC.[C_9_,C_8_,C_7_,C_6_,C_5_,C_4_,C_3_,C_2_,C_1_,C_0_];
CE(x-1).[D_9_,D_8_,D_7_,D_6_,D_5_,D_4_,D_3_,D_2_,D_1_,D_0_] = Di;
@const x = x + 1; };
"cascaded internal connections to associative words in the SCAM
@const rep = rep - 1;
@const x = 0;
@repeat rep
{ "chained blocks connections
CE(x+1).[READi_9_,READi_8_,READi_7_,READi_6_,READi_5_,READi_4_,READi_3_,READi_2_,READi_1_,READi_0_]=
        CE(x).[READo_9_,READo_8_,READo_7_,READo_6_,READo_5_,READo_4_,READo_3_,READo_2_,READo_1_,READo_0_];
E(x+1).BSETi = CE(x).BSETo;
CE(x+1).FSETi = CE(x).FSETo;
CE(x+1).NSi = CE(x).NSo;
CE(x+1).QBi = CE(x).QBo;
CE(x+1).QFi = CE(x).QFo;
CE(x+1).RESULTi = CE(x).RESULTo;
@const x = x + 1; };
END SCAM_Package;
```

hierarchy components (statements 4, 5), namely the **cam_element** and the **complete-control** schematics as depicted in the Figure 1 design hierarchy.

Note that in ispLEVER Project Navigator (Figure 1) and the Device Selector window (Figure 2), I chose the FPGA device LC51024VG from the ispMACH 5000VG family to implement the SCAM.

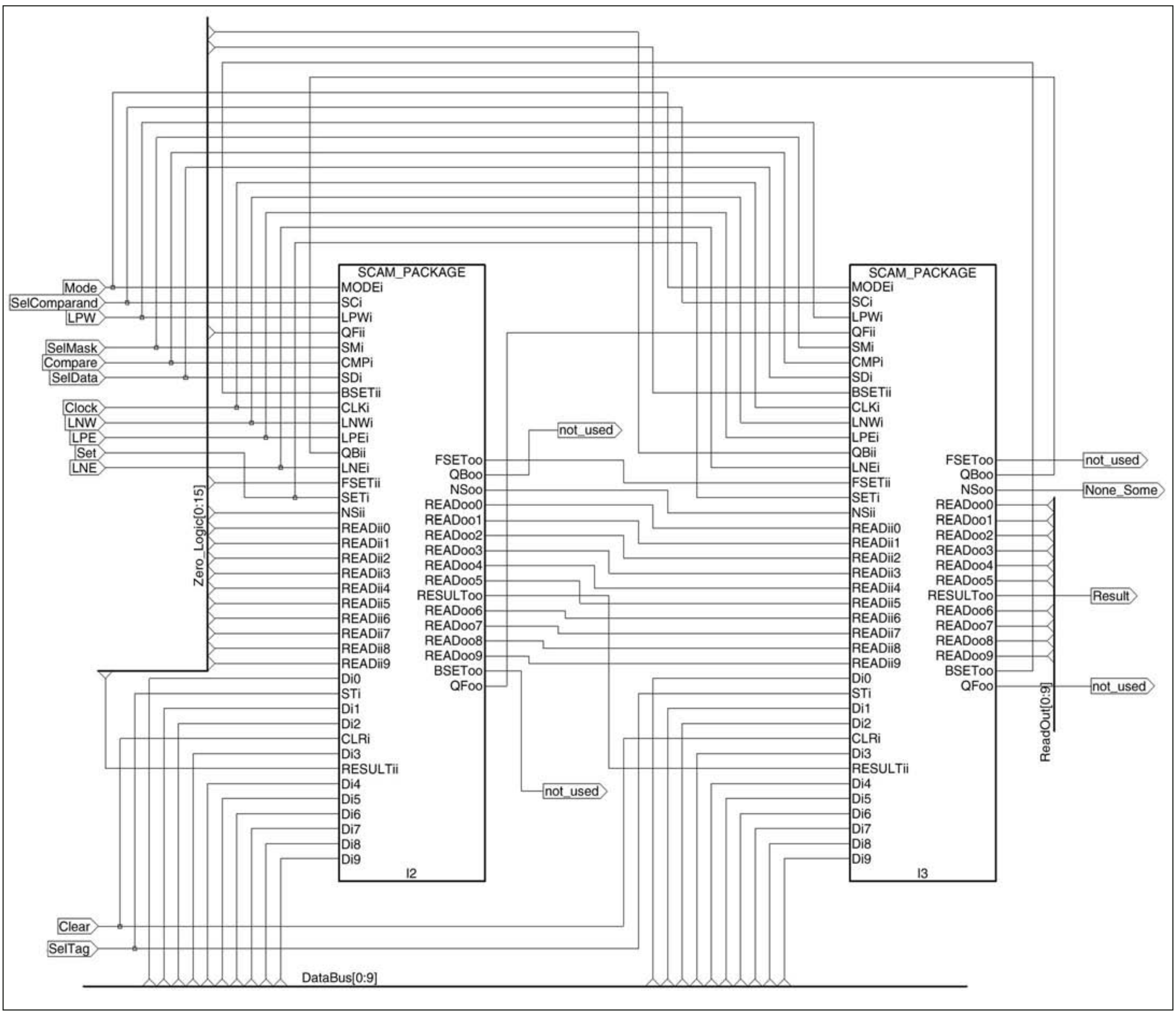
As I mentioned in my previous article, a CAM word is composed of the data bits (multiples of eight), an Element cell, a number of structure cells (or none), and a Tag cell. The problem with schematic editors at this level of design, i.e., assembling the building blocks, is handling the large number of replicated blocks and the exceptional wiring of the first and the last block of CAM words. The first block is directly linked to the control block, and is connected to the SCAM package I/O pins, while the last block is connected to the SCAM package I/O pins. ABEL comes to the rescue to represent the final product.

In Listing 1, the input pins of the first element are declared in statements 15-28, while the output pins of the last element appear in statements 29-36.

The replication of the CAM words is implemented in statements 6-13, where the SCAM-Package is set to contain 1,024 CAM words. The @Expr in statement 7 evaluates the given expression (that is the “x”) and converts it to a string of digits in the default base numbering system. This string and the block (that is, “CE” between the parentheses {}) are then inserted into the source file at the point where the @Expr directive occurs.

I used the @Expr directive in a loop driven by the @Repeat directive in statement 11 that causes the statements 12, 13 to be repeated “rep” times, where the “rep” value (1,024 in our case) is specified by the constant expression in statement 9. By doing this, the

■ FIGURE 4. Cascading SCAM Packages.



EXAMPLE 1

CE(0) FUNCTIONAL_BLOCK *cam_element;*
CE(1) FUNCTIONAL_BLOCK *cam_element;*
.
.
.
.
.
CE(1023) FUNCTIONAL_BLOCK *cam_element;*

ABEL compiler inserts the declarations (shown in Example 1) of 1,024 CAM words into the processed source file.

The output pins of the SCAM-Package are declared in statements 44-51, while its input pins are declared in statements 52-62.

The internal connections common to all associative words in the SCAM are declared in statements 66-71, while cascaded internal connections to associative words appear in statements 72-84.

Processing the design hierarchy in ispLEVER Project Navigator generates the SCAM-Package (see Figure 3) having 39 input signals and 16 output signals, in addition to power pins (not shown in device symbol).

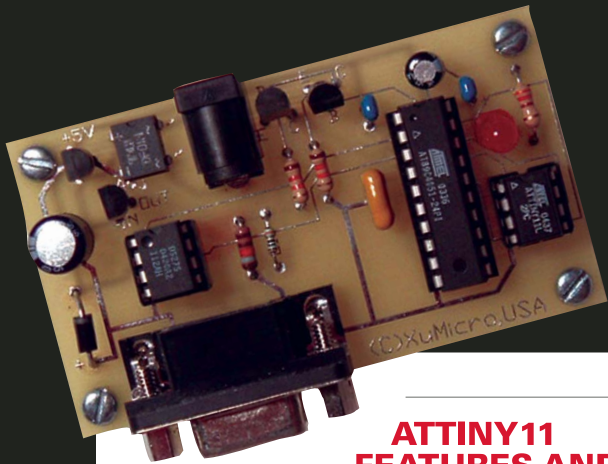
SCAM devices can be cascaded to provide larger data processing engines, as shown in Figure 4. The left-hand side package represents the top of the SCAM chain, while the other package represents the end of the chain and provides the final processing results. The key note about cascading is the negligible signals output from each device (marked "not_used") and the default settings of some signals input to the top-of-chain device (marked "Zero_Logic"). The chain has 12 input control signals; 10 or more data input lines from the computer system's data bus; 10 or more data output lines that may be connected to the computer system's data bus via proper additional hardware to the chain; and two output signals indicating whether or not a match is found for the search within the chain ("Result", "None_Some" signals).

My search for an appropriate FPGA device family to accommodate a SCAM with reasonable capacity was not very successful. I believe that ASIC technology would be more appropriate to achieve an applicable SCAM. However, building my project using ispLEVER tools and FPGA devices gave me the ability to verify my design and to get a glimpse of the real production procedure. **NV**

Programming the 54¢ MICRO

A Device Programmer and a Few Example Programs are All You Need to Start

by G. Y. Xu



We all know that a microcontroller (MCU) is much more complicated than a single TTL logic IC, such as the 7400-series gates. And so it's no surprise that an MCU was much more expensive than a chip of "glue logic." But things have changed recently. MCU prices are falling into the same range as TTL gates. Beginning this year, one of Atmel's eight-bit tiny MCUs, the ATtiny11, can be purchased for 54 cents — and even less if you buy a hundred of them!

This is a great boon to both experimenters or developers. In this article, I'll show you how to take advantage of it. First, you'll need to know what resources this chip has, and then how you can do something useful with it.

ATTINY11 FEATURES AND A "PROBLEM"

The ATtiny11 is from the family of Atmel's AVR RISC (reduced instruction set computer) microcontroller series. It is available in either an eight-pin DIP or SOIC package. Either way, the pinout is the same and is shown in Figure 1. Other than the Vcc, RESET, and GND pins, it offers a maximum of five digital I/O pins — PB0-PB4 —including two analog inputs (PB0 and PB1).

To release the XTAL1(PB3) and XTAL2(PB4) pins for I/O use, you will need to use the internal 1 MHz RC oscillator as a clock source. For most projects, this is fine and you won't have to add an external crystal. But keep in mind that the RC oscillator frequency is less accurate, and is both Vcc and temperature dependent. If you need precise timing, you will have to use a crystal.

PB1 can also act as an external interrupt (INT0) pin and PB2 can act as a timer interrupt (T0) pin. The chip has an interrupt handling mechanism, and its eight-bit timer can be used as a timer/counter in response to external or internal events.

The ATtiny11 has 1K bytes of Flash program memory, and just as the other AVR micros, it contains 32 general-purpose eight-bit wide registers named R0-R31.

These resources make it a powerful MCU. It may seem that the 1K of program space isn't big enough, but in many cases, it's sufficient. However, when it comes to the method used to program the Flash memory, the situation is different than other AVRs — and it presents a unique problem.

For most other AVR MCUs, there is an SPI (serial peripheral interface) port built in and it is used for Flash programming with a single 5V

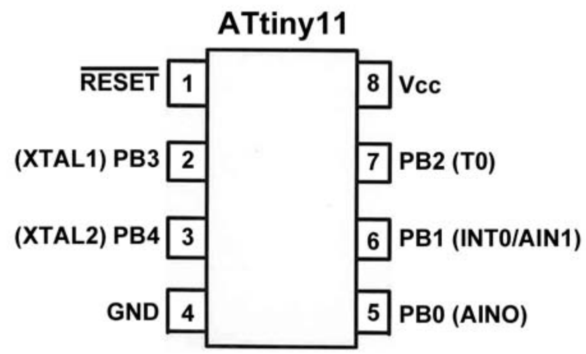
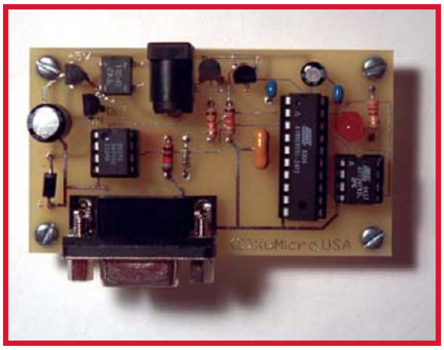
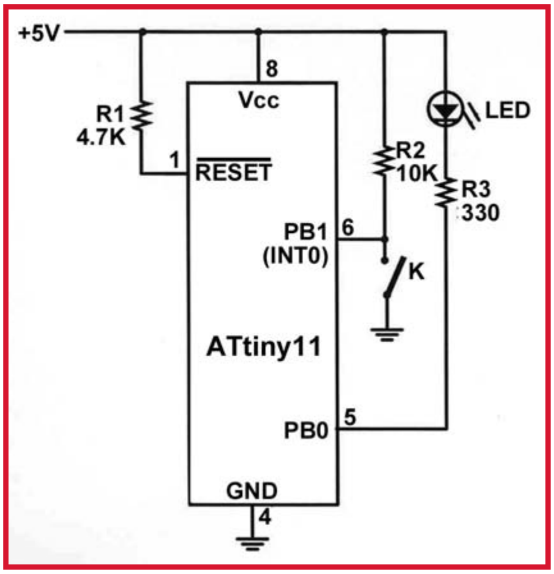


Figure 1. ATtiny11 pinout diagram.



➡ **Photo 1.** The AVRHVP-1 programmer.



➡ **Figure 3.** First Example Circuit.

power rail. But, the ATtiny10/11 are the only two AVRs which don't have the SPI interface! The only way to flash them is to use Atmel's proprietary scheme called High-Voltage Serial Programming. And this method is not as simple as using SPI.

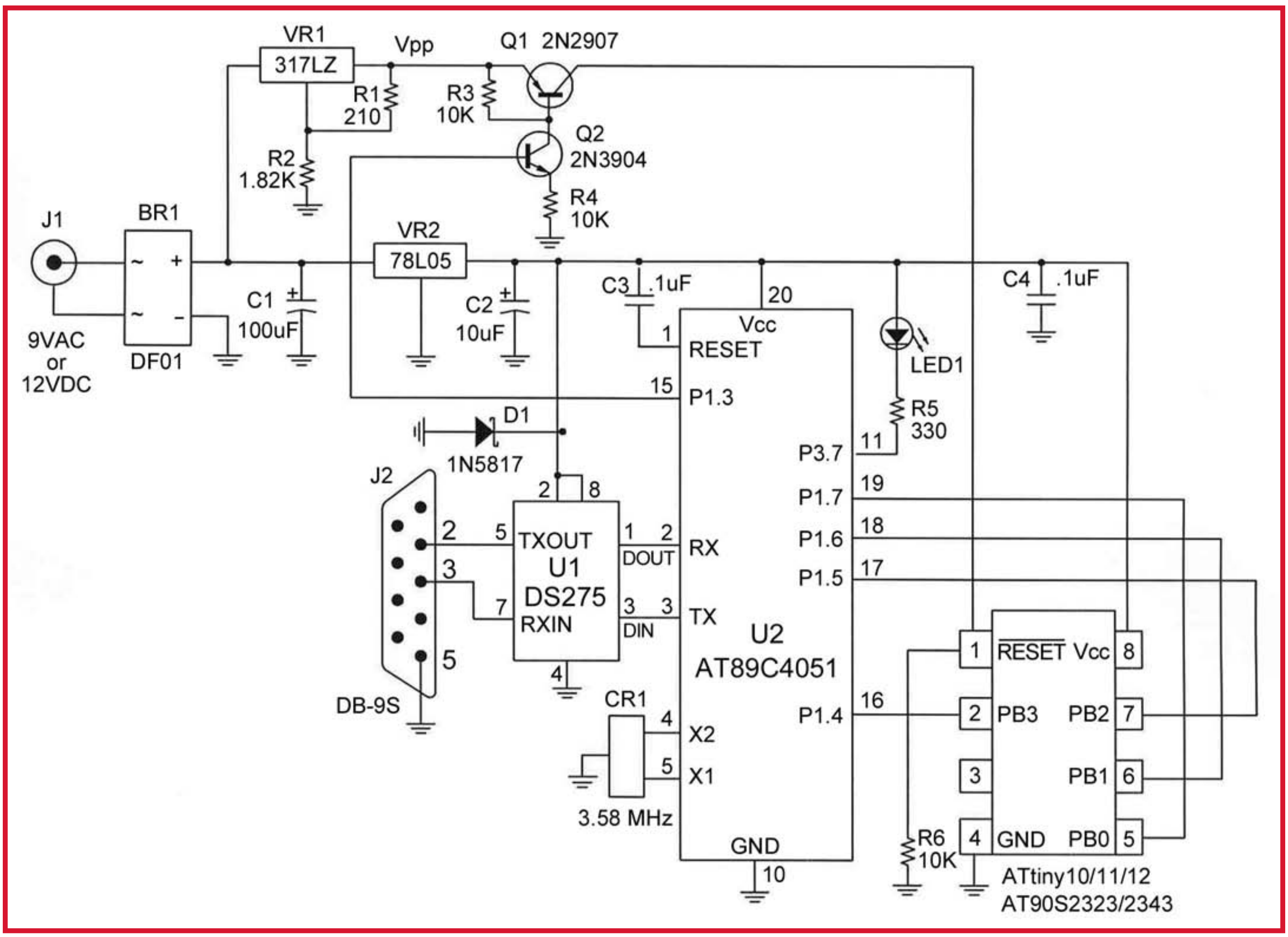
Because we want to save money by using these inexpensive chips, a new high-voltage (12V) device programmer has been developed.

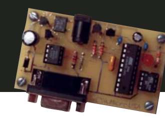
THE AVR HIGH-VOLTAGE SERIAL PROGRAMMER

Photo 1 shows the constructed AVR High-Voltage Serial Programmer (we call it AVRHVP-1), and it's schematic is shown in Figure 2. Primarily it's used for the ATtiny10/11, but it can also program the ATtiny12 and ATtiny2323/2343 chips, because these devices support both SPI and the high-voltage method.

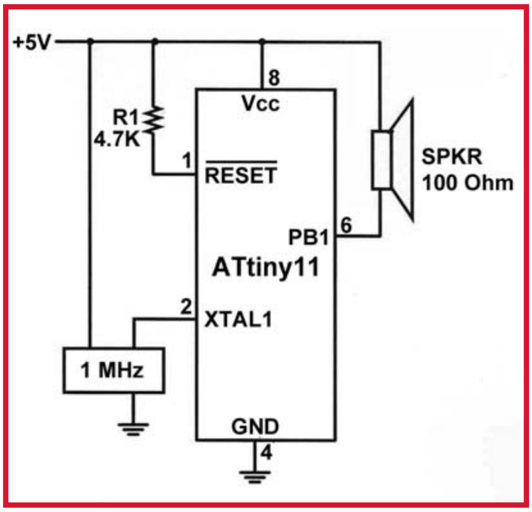
The AVRHP-1 programmer consists of only two chips: an Atmel 8051-like Flash MCU (AT89C4051) and a Dallas Semiconductor RS-232 interface chip, (DS275). The 4051 has 4K bytes of program memory which is barely enough to hold the firmware for programming chores and communication with the host PC. The DS275 is used to convert RS-232 voltage levels to TTL, and vice versa.

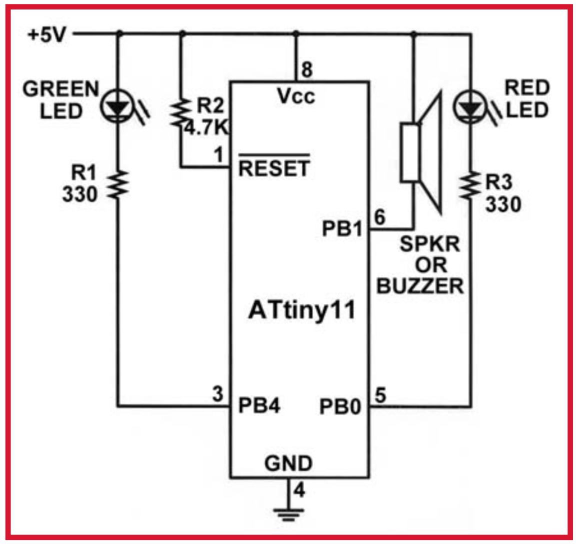
➡ **Figure 2.** Schematic of the AVRHVP-1 programmer.





➨ **Figure 4.** 440 Hz Music Tone generator.





➨ **Figure 5.** Third Example Circuit.

The 12V programming high-voltage Vpp is generated by a voltage regulator VR1 (317LZ) through a precision resistor divider made from R1 and R2. These two resistors are specified at 1% tolerance to get accurate voltage output.

Vpp is then applied to the chip RESET pin only after power-up and chip reset. Transistor pair Q1,Q2 acts as a switch to block or allow Vpp to go through under the control 4051 port pin P1.3. When P1.3 is low, both Q1 and Q2 are cut off, so the pull-down resistor R6 provides a way to reset the ATtiny11 to ground. When P1.3 is high, both Q1 and Q2 are turned on and the 12 Vpp is applied to enable the chip's programming mode.

Ceramic resonator CR1 clocks the 4051 MCU, allowing it to operate at 9600 bps. LED1 indicates the programming status.

In order to make the programmer more flexible, its power supply is designed to be either 9 VAC or 12.5 VDC. The bridge rectifier DF01 and low voltage regulator VR2 (78L05) provide +5V power for all chips. Capacitors C2 and C4 are used to smooth the DC output.

With 4K bytes of Flash memory, the programmer can (barely) store the code for all necessary operations: Blank Check, Erase Chip, Read/Write flash, Read Signature bytes, and Verify programming. The lack of any extra room forces the programmer to only accept binary file input. It doesn't accept Hex format files.

To ease this requirement, we provide a software program named HEX2BIN.EXE to let you convert your Hex file into a binary file, compatible with the programmer. Now let's see how to use this programmer to do something with ATtiny11.

BLINKING LED

The simplest application to demonstrate MCU programming is LED ON/OFF control. Figure 3 shows the actual circuit, and Listing 1 is the AVR assembly language source code.

After power-up and completing the chip reset, the LED connected to PB0 (pin 5) is alternately driven high and low, for a half second each, caus-

➨ **Listing 1.** Single and Double Blinking LED program.

```
; LED1N2.ASM: Single/Double Blinking LED program
; 1 Hz blinking LED driven by Tiny11/12 AVR working at 1 MHz
; LED is connected to AVR PortB Bit_0 (Pin 5 for ATtiny11/12)

; Double blinking LED is generated by Low-level trigger INT0
; at PortB Bit-1 (Pin 6 for ATtiny11/12)

.include "TN11def.inc"        ; Port definitions here
.cseg
.org 0
         rjmp     RESET
         rjmp     INT0_LED2   ; INT0 is used to cause double-blinking LED
RESET:
         ldi      r16, $80
         out      SREG, r16   ; Enable any Interrupt
         ldi      r16, $40
         out      GIMSK, r16  ; Enable INT0
         ldi      r16, $00
         out      MCUCR, r16  ; INT0 = Low-Level triggered
         sbi      DDRB, 0     ; config DDRB bit-0 as output for LED
LED1:
         cbi      PORTB, 0    ; LED=ON
         RCALL    DLhalfS
         sbi      PORTB, 0    ; LED=OFF
         RCALL    DLhalfS
         rjmp     LED1        ; repeat again
;————————————————————————————————————————————————
;the delay = 1/2 sec at 1 MHz

DLhalfS:
         LDI      R20, 3
calop:
         LDI      R19, 248
malop:
         LDI      R18, 248
LOOP1:
         DEC      R18
```

continued ...

Listing 1 continued

```
        brne     LOOP1
        DEC      R19
        brne     malop
        DEC      R20
        brne     calop
        RET
;————————————————————————————————————————————
INT0_LED2:

rept2:
        cbi      PORTB, 0    ; LED=ON
        RCALL    DLhalfS
        sbi      PORTB, 0    ; LED=OFF
        RCALL    DLhalfS
        cbi      PORTB, 0    ; LED=ON
        RCALL    DLhalfS
        sbi      PORTB, 0    ; LED=OFF
        RCALL    DLhalfS
        RCALL    DLhalfS
        RCALL    DLhalfS
        RCALL    DLhalfS
        rjmp     rept2       ; repeat again
;————————————————————————————————————————————
```

ing single blinks at a frequency of 1 Hz. Here, the half second delay routine drives the blink rate.

Pressing switch K drives PB1 low, triggering an interrupt to the MCU and causing it to jump to the interrupt service routine INT0_LED2, where the LED is driven to double blinking. Therefore, the LED blink rate can be doubled, depending on whether the MCU has entered the interrupt routine. The ATtiny11 can be interrupted by either high or low signal inputs; here we chose the low level trigger.

As described by my previous article[1], you can use the Atmel freeware AVRASM.EXE to assemble the source code in Listing 1 to get a Hex file, that is LED1N2.HEX; then use the provided software HEX2BIN.EXE to convert it to LED 1N2.BIN; then power up and run the AVR High-Voltage programmer; in the host PC, enter this binary file name to let it transfer the binary data to the programmer.

After programming the ATtiny11, build the circuit shown in Figure 3 and verify its operation. This simple circuit can be built on any solderless breadboard.

REFERENCE

[1] G.Y. Xu: "Play the AVR HyperTerm," *Nuts & Volts Magazine*, February 2005.

440.0 HZ STANDARD MUSIC TONE GENERATION

Figure 4 is a simple but very accurate circuit that generates the 440.0 Hz standard music tone. It can act like a "tuning fork" for musical instruments. For example, you can use it to check whether your piano is out of tune by playing its A4 key.

To get exact 440.0 Hz tone, both hardware and software must be fine-tuned. Because the ATtiny11's built-in RC oscillator is not accurately 1 MHz, we replace it with the 1 MHz crystal oscillator as shown. The speaker needs to have good response to audible frequencies, so we'll choose a 2.5" 100 ohm speaker.

Since the factory has pre-programmed the ATtiny11's internal "fuse bits" to select the built-in RC oscillator, we'll need to re-program those in order to use an external

```
;ATonTn11.ASM: 440 Hz Standard Music "A" tone generator
.include "TN11def.inc"      ; Port definitions here
.cseg
.org 0
        sbi     DDRB, 1     ; config DDRB bit-1 as output
        sbi     DDRB, 0     ; config DDRB bit-0 as output

        cbi     PORTB, 0    ; LED=ON

AGAIN:
        cbi     PORTB, 1    ; PB1=LOW; 2us
        rcall   DL1132us    ;
        NOP                 ; 1us
        NOP                 ; 1us
                            ;            1136
                            ;          _______       __
        sbi     PORTB, 1    ; PB1=High     |       |       |
        rcall   DL1132us    ;          ___|       |_______|
                            ;                      1136
        rjmp    AGAIN       ; 2us
;——————————————————————————————————————————————————————
;delay 1132us at 1 MHz

DL1132us:
        LDI     R20, 0           ; 1us
LOOP1:
        DEC     R20              ; 1us \ 3*256 = 768 us
        brne    LOOP1            ; 2us /

        LDI     R21, 119         ; 1us
LOOP2:
        DEC     R21              ; 1us \ 3*119 = 357 us
        brne    LOOP2            ; 2us /

        RET                      ; 4us
;——————————————————————————————————————————————————————
;rcall is 3us;  Total delay = 1132 us
```

➡ **Listing 2.** The Standard 440 Hz Music Tone Generation program.

oscillator.

A fuse bit programming facility is not included in the AVRHVP-1 programmer since there is not enough program memory to support this. For this reason, another special programmer AVRHVP-2 has been developed, which handles only fuse bit programming, and as well, writing the "lock bits" to hide the binary code functions.

Listing 2 shows the software. To generate the accurate 440 Hz frequency tone, an infinite loop of 1,136 µS high and low voltage is alternately applied to the speaker (1,136 µS is the half period corresponding to 440 Hz.)

The key routine here is the DL1132 µS delay routine, but every other instruction counts as well. For example, setting pin PB1 high or low takes 2 µS each, and the call overhead to DL1132 also takes 2 µS. Adding them all up gives us exactly 1,136 µS.

With such meticulous calculations, the circuit output tone is exactly 440.0 Hz when measured by a frequency meter. As a comparison, if you don't re-program the fuse bits and use the built-in RC oscillator, the frequency meter will show quite different readings, such as 495.7 Hz.

PARTS LIST

- C1 — 100 µF 16 volt radial electrolytic capacitor
- C2 — 10 µF 16 volt radial electrolytic capacitor
- C3, C4 — 0.1 µF ceramic capacitor
- R1 — 210Ω 1/8 watt metal film precision resistor, 1% tolerance
- R2 — 1.82K, 1/8 watt metal film precision resistor, 1% tolerance
- R3, R4, R6 — 10K, 1/4 watt carbon resistor
- R5 — 330Ω 1/4 watt carbon resistor
- U1 — RS-232 transceiver DS275 from Dallas Semiconductor
- U2 — AT89C4051 Flash microcontroller (programmed)
- Q1 — PNP transistor 2N2907
- Q1 — NPN transistor 2N3904
- BR1 — Bridge rectifier DF01
- VR1 — 317LZ voltage regulator
- VR2 — 78L05 voltage regulator
- D1 — Schottky diode 1N5817
- LED1 — General-purpose light emitting diode
- J1 — Power jack
- J2 — DB9F connector
- CR1 — 3.58 MHz ceramic resonator
- Miscellaneous: Eight-pin machined socket, 9VAC or 12.5VDC power supply, etc.

NOTE: The following items are available from:
G.Y. Xu, P.O. Box 14681, Houston, TX 77021
Phone: (713) 741-3125

1. Assembled and tested AVRHVP-1 programmer — $29.95
2. PCB and programmed AT89C4051 — $10.00

Please visit www.geocities.com/xumicro for ordering information.

HAPPY BIRTHDAY SONG

As the last example program, in Listing 3 (go to the *Nuts & Volts* website for Listing 3; www.nutsvolts.com), we show the familiar Happy

Birthday song composition. Figure 5 is the corresponding circuit to build it. To add to the birthday atmosphere, two LEDs are turned ON/OFF alternately in program.

Just as for any song composition, we need to write the music note subroutines for each note that will be used in the song. The basic idea on note creation is the same as described for 440 Hz music tone: find the note's frequency, then calculate its half period T/2; then drive the speaker high or low in the half period.

For example, in the 784 Hz "G5" tone subroutine, T/2 = 638 µS, so the speaker needs to be driven high for 638 µS, then low for 638 µS, and so on.

To count this time, we utilize the ATtiny11's timer interrupt. This eight-bit timer is an up counter; it increases its count every clock cycle (that is one microsecond); when reaching a count of 256, it overflows to zero and generates an interrupt, and then increases one count per µS again. Each overflow interrupt causes the MCU to execute its associate interrupt service routine, in this case (see Listing 3), it is TIM-OVF.

Instead of letting the timer count from zero, we set it to start at 240, so the timer will overflow each 16 µS. Therefore, for T/2=638 µS, the needed number of overflows is 638/16=40.

Each music note takes some time to play. So the above half period high/low must be repeated a number of times. We chose a value of 150, which sounds good. Of course, you can change it if you find it too short or too long.

After writing all note subroutines, the last step is to call these notes to form a song, as shown in the main program of Listing 3. Of course, you need to listen to it, then change it as necessary, and do this for several iterations until you get the music how you want it.

SUMMING UP

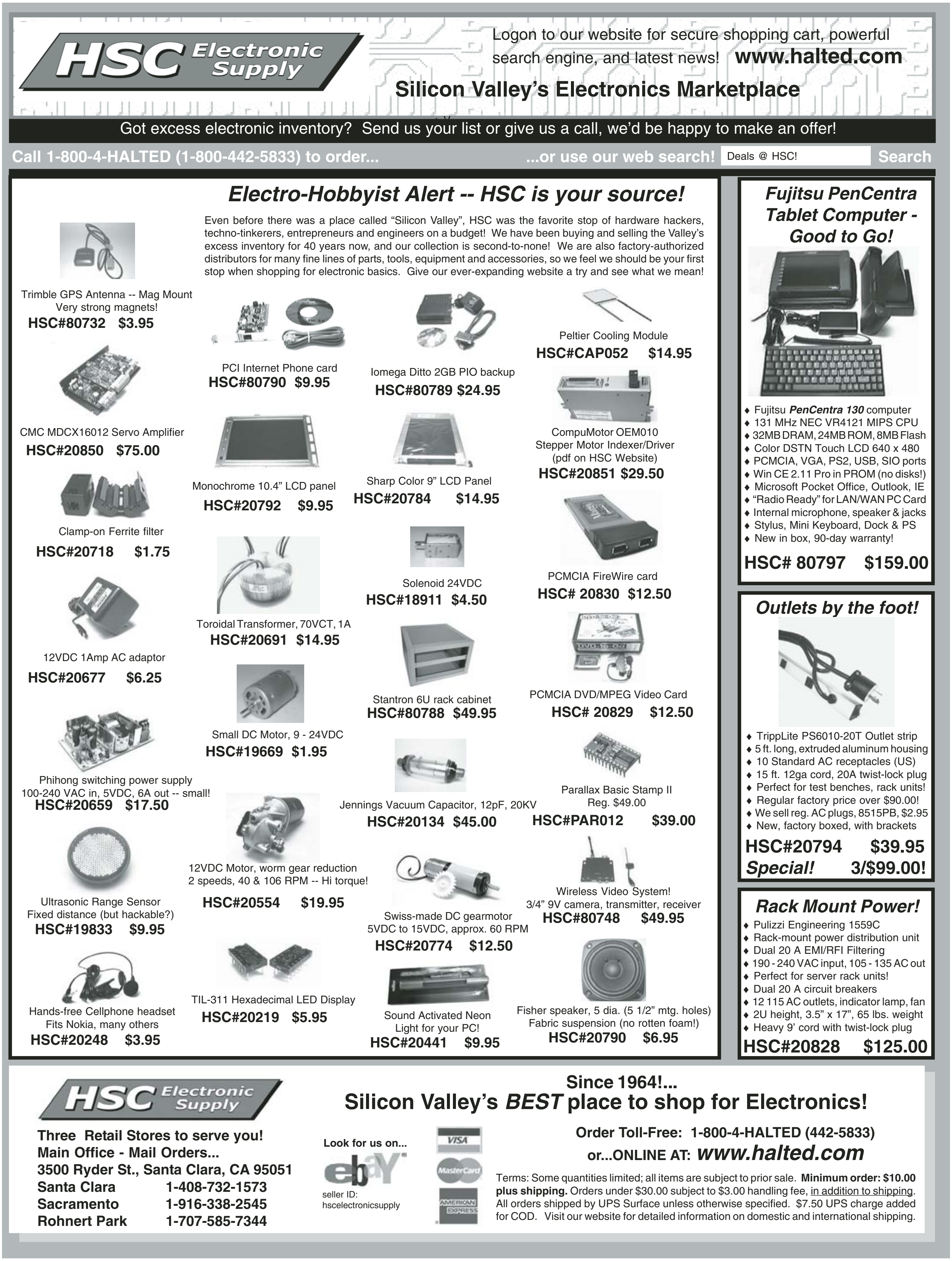
In this article, I presented three example programs for the ATtiny11 application. But the list can be endless and is only limited by your imagination.

Perhaps the widest use for the ATtiny11 will be in single-chip music composing. And since its price is so low, you won't have to care about how many chips you'll need.

You may even want to build a "chip music library!" **NV**

ABOUT THE AUTHOR

G.Y. Xu is an Electrical Designer specializing in microprocessor/microcontroller systems design and development, both in hardware and software. He can be reached by email at **gyxu@cmpmail.com**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The Magnetic Amplifier

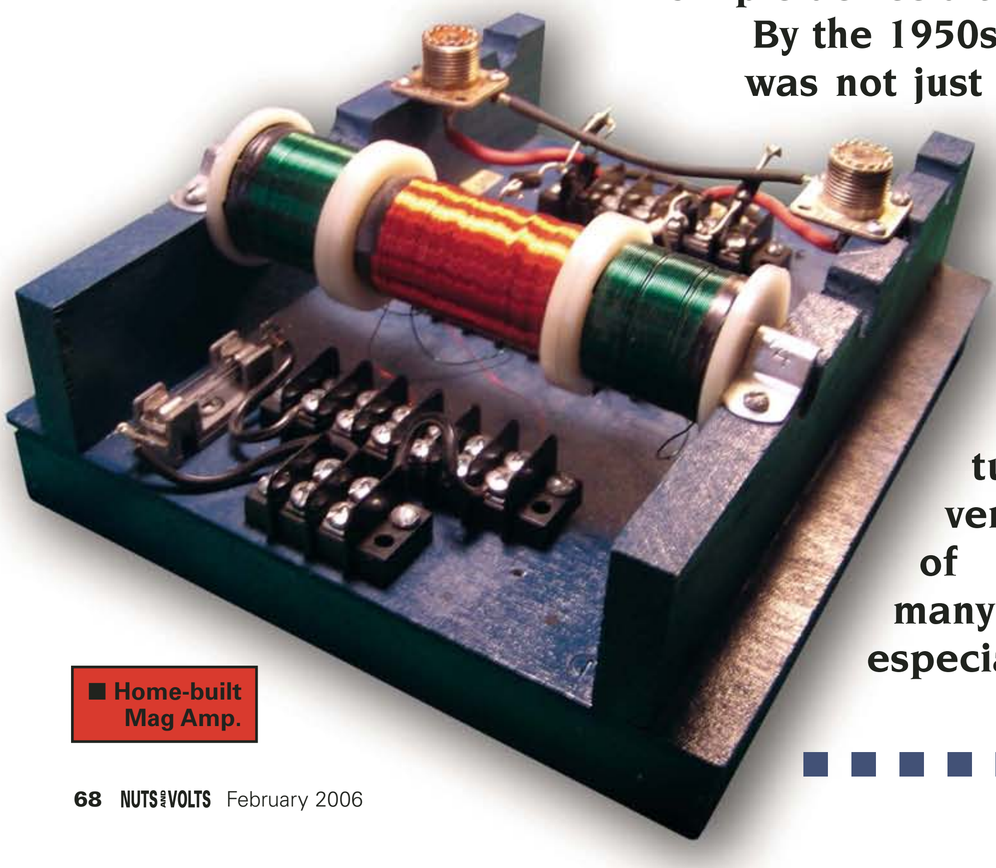
A Lost Technology of the 1950s

Anyone can build it!

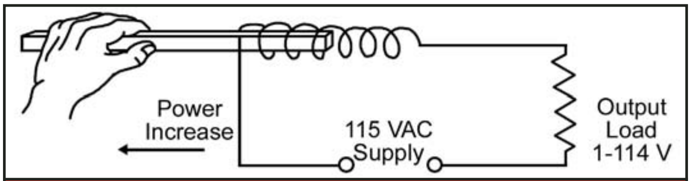
by George Trinkaus

Most folks believe that first came the vacuum tube and right on its heels came its successor, the transistor — an historical fact, correct? Not really. Another competitive control technology developed by US and Nazi engineers came in between. It was the magnetic amplifier. Rugged, dependable, EMP-proof, and capable of handling greater electrical powers than either transistor or tube, the magnetic amplifier is a simple device that can be built by anyone.

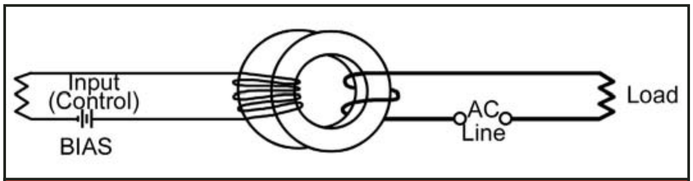
By the 1950s, the magnetic amplifier was not just an experimental dream languishing in some inventor's notebook. Nor was this ingenious technology sitting unexploited in patent archives. The mag amp was in manufacture in a number of versions and had a clique of boosters, including many electronics engineers, especially within the US Navy.



Home-built Mag Amp.



■ FIGURE 1. Principle of Operation.



■ FIGURE 2. Saturable Reactor.

The mag amp is an American invention and has been used in heavy electrical machinery regulators since 1900. In the 1940s, the Germans took the American's relatively crude device, assigned their best scientists, invested millions, and developed it into a faster, lighter electronic tool competitive with the vacuum tube in performance but more simple and dependable. It's also much more rugged. A mag amp can be made to be nearly indestructible.

The Germans used the mag amp in electric brakes for trucks, streetcars, and locomotives. They used it for high-voltage utility-power controls and even for early computers.

Appreciating its indestructibility, the Nazi military used it in gun stabilizers, in automatic pilots, and in missile-guidance, including the rocket stabilizer and steering systems of the V-2.

After the war — like German rocketry itself — the mag amp emigrated to the US, where it got further development by enthusiastic American engineers. By 1951, a Navy engineer could write, "Electronics engineers are now forced to concede recognition of the magnetic amplifier, as it has demonstrated its value beyond question in many fields dominated by the electron tube."

Simplicity

The mag amp, like the vacuum tube and transistor, is an electrical control valve. When a smaller circuit controls another circuit's larger flow, that's the definition of an "amplifier."

A mag amp can be put in series with any circuit carrying an alternating current and control that flow. No external power supply is required to run the device. The simple mag amp is just a core of iron or ferrite with some coils of wire wound around it.

One other basic component is the rectifier. Today, rectifying diodes are compact, easily available, and cheap. The old selenium rectifiers used back in the 1950s were large, cumbersome, and expensive.

A variety of ferrite core materials are also available to today's builders.

With some spools of wire, a ferrite rod, and a couple of diodes, you can throw together a little high-frequency mag amp on a Sunday afternoon.

Compare the construction challenge of a vacuum tube or transistor. And the mag amp can handle voltages and currents that you would never put into the average transistor or tube.

How it Works

The mag amp is a sort of variable choke. It controls the impedance (opposition) to alternating current in a coil by controlling the magnetic condition of the core on which the coil is wound. This is done by energizing another winding on the core called a control coil. Depending on the energy in the control coil, the core's permeability (its receptivity to magnetism) can be varied by degrees, thus controlling a larger AC flow.

Fully energized, the control coil can reduce the permeability of the core to zero, in which case the core is said to be saturated. Then it becomes so magnetically unresponsive it's like the core has been removed.

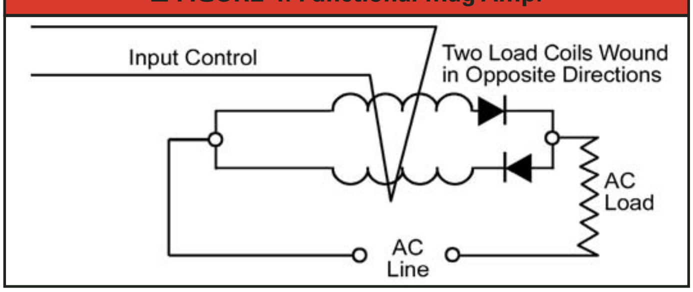
Figure 1 is a way of showing the principle. With the core completely within the coil, the impedance to the flow is high, permitting perhaps only a fraction of a volt to appear across the load. Pulling the core out causes the load voltage to rise progressively to 115. Since it took only a few watts of muscular energy to move the iron core within the coil, which may, in turn, control several horsepower, the device is an amplifier.

Figure 2 is another demonstration. This qualifies as a saturable reactor. This circuit could be for a dimmer for theater stage lighting. Add a diode, and you have a basic mag amp (see Figure 3). The larger coil is the control coil. The smaller is called the loading coil.

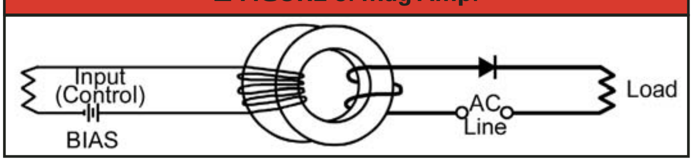
The diode rectifier makes the load current unidirectional, which assists the control winding in saturation. Considerably less power is now required, making it a more potent amplifier.

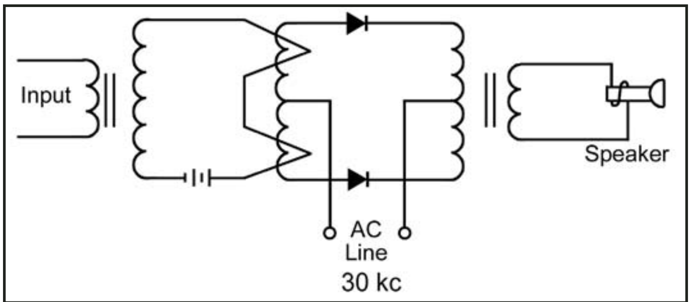
This mag amp, however, will function as a step-up transformer, which would be undesirable since it

■ FIGURE 4. Functional Mag Amp.

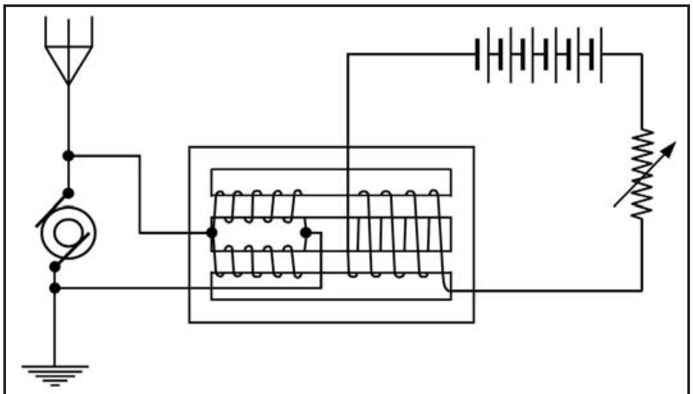


■ FIGURE 3. Mag Amp.





■ FIGURE 5. Mag-amp Audio Amplifier (push-pull).



■ FIGURE 6. GE Mag-amp Modulator by Alexanderson.

would send energy back into the control circuit. This effect is cleverly cancelled by running the AC through a pair of parallel loading coils which are wound in opposite directions.

Figure 4 is your basic functional mag amp represented by the appropriate schematic symbols. The control coil symbol is a single sharp angle-line, but the control coil actually has many more turns than the loading coil.

How many turns? The rule of thumb is control-coil ampere-turns equals loading-coil ampere-turns plus sufficient extra turns to saturate the core.

(Much of the how-it-works above is from *Magnetic Amplifiers* by the US Navy, 1951, recently republished.)

Uses

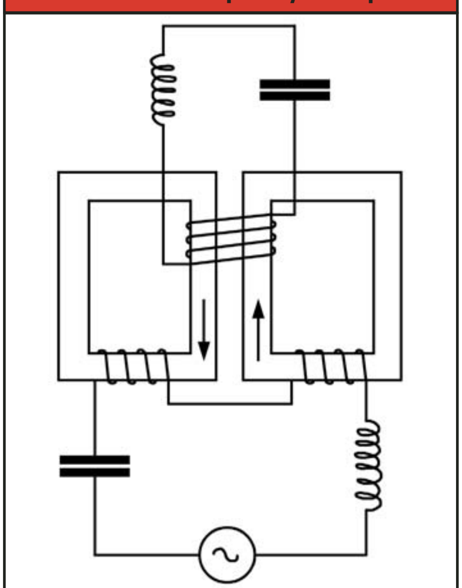
The mag amp still has industrial uses in the control and regulation of power utilities and big electric motors, as in locomotives, but its most fascinating applications — mostly forgotten — are in electronics.

The mag amp can modulate, switch, invert, convert, multivibrate, audio-amplify, radio-amplify, frequency-shift, phase-shift, and multiply. Stages can be cascaded. Simple feedback techniques enable gains in the millions.

The mag amp can even compute. Trouble-proof magnetic binaries replaced the less reliable vacuum tubes used in some early digital computers.

Figure 5 shows the incredibly simple circuit for a mag amp audio amplifier.Mag-amp audio would be a challenging pursuit for some adventurous audiophile. But the mag-amp electronics which engaged this writer is in radio.

■ FIGURE 7. Frequency Multiplier.



Mag Amps in Radio

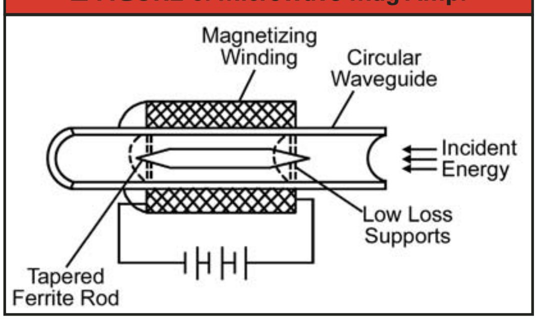
The first patent for a mag amp was in 1903, but little attention was paid until 1916 when radio pioneer E.F.W. Alexanderson seized on the idea as a means of controlling the giant rotary alternators he was using for high-power radio transmitting (at 10,000 to 100,000 cycles). The *Magnetic Amplifier Bibliography* (by the US Navy, 1951) lists three Alexanderson patents in 1916 and three more in 1920, the last titled "Transoceanic Radio Communication."

The mag amp can turn the alternator on and off for telegraphy and vary the signal for speech modulation (see Figure 6).

The frequency limits of an alternator are low, so the mag-amp was reinvented in that era as a frequency multiplier (doubler, tripler), as seen in Figure 7. The *Bibliography* cites many radio-transmitter frequency-multiplier patents up through the 1920s. These are simple circuits compared to those of vacuum-tube frequency changers that came later.

Early mag amps with solid iron cores never got above a few hundred kilocycles. Powdered-iron cores, the ceramic-iron-oxide composition known as ferrite, and later the ultra-thin magnetic tapes liberated the mag amp, so by the 1950s the limit was up to a megacycle and switching rates were in microseconds, suitable then for computer applications. Techniques for the modulation even of microwave frequencies were also developed in the 1950s (see Figure 8).

■ FIGURE 8. Microwave Mag Amp.



My Home-built Mag Amp

I wanted to see if a mag

amp could modulate a Tesla coil (see Figure 9), as Alexanderson modulated his big alternator-transmitter. I used the schematic in Figure 4. The Navy booklet, *Magnetic Amplifiers* served as a reference.

I first obtained a ferrite rod (material #33), six inches by just under 1/2-inch diameter. I got it surplus from Alltronics, for about $5, but it's no longer available, though they do carry a four-inch for $5 (www.alltronics.com.) Another source for rods is Surplus Sales of Nebraska (www.surplussales.com). From Alltronics I also got spools of magnet wire — #26 for the two loading coils and #30 for the control coil.

I wound my coils, not directly on the ferrite, but on acrylic tubing, 1/2 inch inside diameter (from Tap Plastics), which I could slip over the rod. A section of the tubing and a couple of nylon fender washers from the local hardware store made a well insulated spool or coil form on which to wind the coils on my winding jig. The loading-coil spools were 1-1/8 inch wide, the control coil two inches wide. For the loading coils, I wound 13 layers, 860 turns of the #26 wire, laying on some electrical tape for extra insulation between each layer. I wound the two loading coils in opposite directions. The control coil took 400 feet of the #30 wire.

A mag amp is frequency specific according to the size of its loading coils. (Thus, an audio amp would be quite large.) I wanted 180 kilocycles, and I determined the number of turns experimentally.

For the rectifiers, I used eight 1,000-volt, three-amp 1N4008 diodes, four in each leg (three for a $1.00, from All Electronics, www.allelectronics.com). The mag amp was now safe to 4,000 volts and could handle the output of my solid-state Tesla coil.

Performance

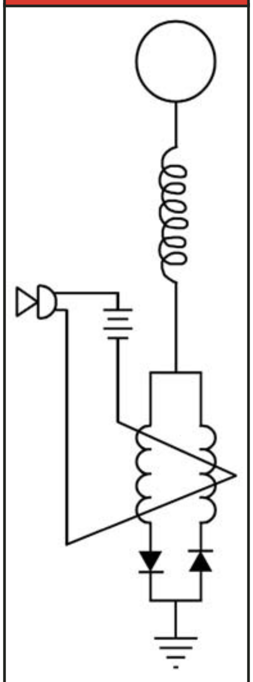
So that I could observe the mag amp's performance with my signal generator and oscilloscope, I replaced the 1N4008s with two low-power signal diodes. In series with the control coil, I put a 12-volt battery and a telegraph key, as a convenient switch. The mag amp is frequency-specific; you design it for a particular range. Keyed on and off, the mag amp showed response from 155 to 200 kilocycles (a range that happens to fall within the license-free experimental radio band called LowFER).

What a versatile device! At a particular frequency, operating the key would increase or decrease the amplitude of the wave as traced on the scope. At another frequency, the keying would shift the frequency back and forth, and at another it would shift the phase.So this one little device, depending on how it was tuned, could do on-off keying (CW), amplitude modulation (AM), frequency-shift keying (FSK), frequency modulation (FM), or phase-shift keying (PSK), including bi-phase-shift keying (BPSK), which is a common mode of digital transmission. Placed in the ground circuit of my solid-state Tesla-coil, the little mag amp showed that it could do all of the above with more than 3,000 oscillating volts running through it. This would be quite a task for a vacuum tube and probably beyond any transistor.

And I built it myself. **NV**

George Trinkaus' High Voltage Press is at teslapress.com

FIGURE 9. In Tesla Coil Circuit.



Magnetic Amplifier Modulates Tesla Coil

Getting Started With PICs

⟹ Microchip PIC-Based Resistor Checker

⟹ In my basement lab, I have racks of components including a large plastic draw cabinet full of resistors. When I order new resistors, it becomes a tedious job of cutting the resistors from their tape and reel packaging and then placing them in the proper plastic drawer. It's one of those jobs I would like to hand off to my eight-year-old daughter. She often comes down to see me and asks if she can help me with anything. It seems I always have some clean-up job to do, but that isn't very exciting.

Then I thought about having her put these resistors away for me. The catch is she doesn't know 10K from 10 ohms. Add to that the color coding and the whole thing gets too confusing. Then it occurred to me, why not let a PIC micro A/D port read the resistor and light an LED next to the plastic tray where the resistor could be stored. This would reduce the job down to picking up a resistor, placing it across two probes, and then putting it in the tray where the light is lit. That is something she is more than capable of handling and might even be fun for a while.

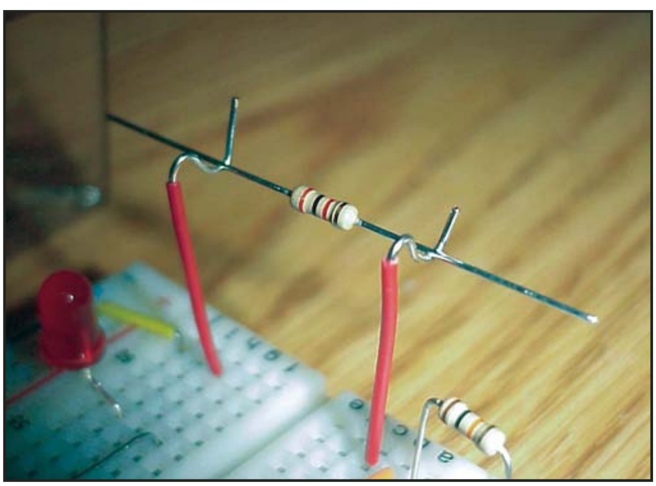
This article describes this project and shows how easy it is to use the A/D port with the PICBasic Pro compiler. In fact, I was able to write the code within 31 commands so this could be done with the sample version of PICBasic Pro which you can download from **www.melabs.com** for free.

by Chuck Hellebuyck

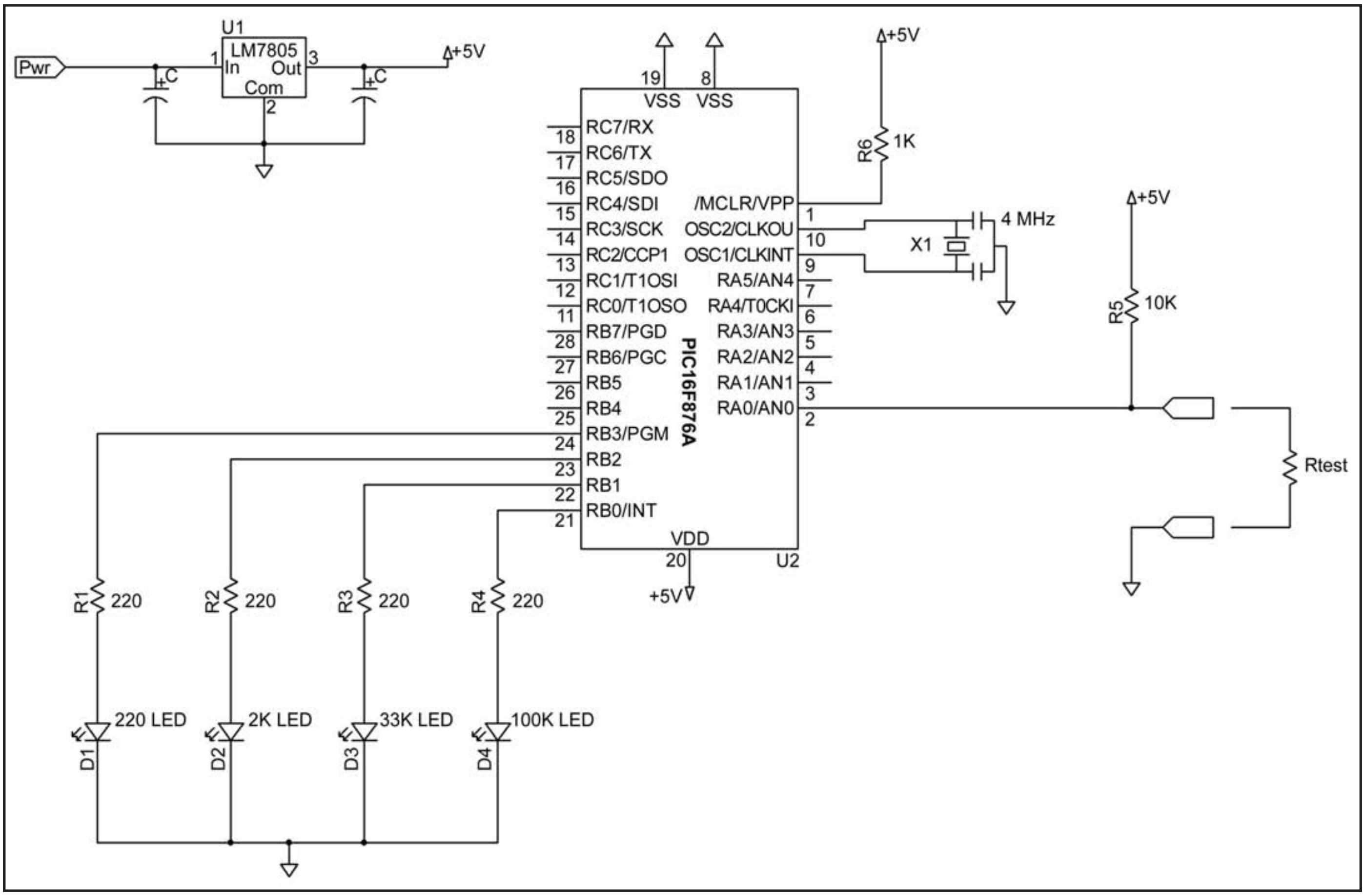
I will use a PIC16F876A for this project which is overkill since it has 22 I/O, 8K of memory, and five A/D ports. The reason I selected it is for three reasons: 1) the sample version works with this chip; 2) I have tons of them lying around; and 3) I may want to expand this setup to measure other components, such as a capacitor tester and seven-segment LED display tester to check for common anode or cathode, and who knows what else I can come up with. With the 16F876A, I have all the I/O and code space I will need.

The trickiest part of the project was to get a set of probes that were easy for her to use. I decided to build two "Y" shaped probes that would fit into a breadboard, as seen in Figure 1. This allows her to set the resistor in place and then let go. Very little current will run through the resistor, but having her set the resistor down in the probes and let go makes her mom more comfortable that she isn't going to be electrocuted by one of dad's creations. It also makes it easier to prevent her fingers from getting in the way of a connection.

I made this



⟸ FIGURE 1. Y-shaped probes in a breadboard.



⇑ FIGURE 3. The schematic.

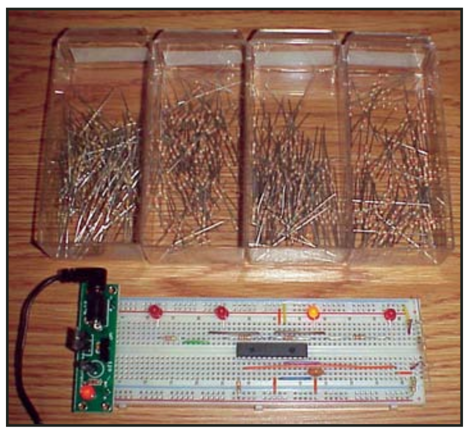
setup work for four different resistors since I knew the latest order I got had only four values, but this could easily be expanded beyond that. This required four LEDs — one for each tray — to be controlled by the PIC and only one would light up at a time to indicate which tray the resistor should be placed in. After placing the resistor in the probes, she would watch for which LED was lit and then pick up the resistor from the probes and place it in the tray next to the lit LED.

As it turned out, she really enjoyed working with this setup. Even my teenage sons thought it was "cool." It's not often that dad's electronics can impress this bunch. The full setup is shown in Figure 2.

HARDWARE

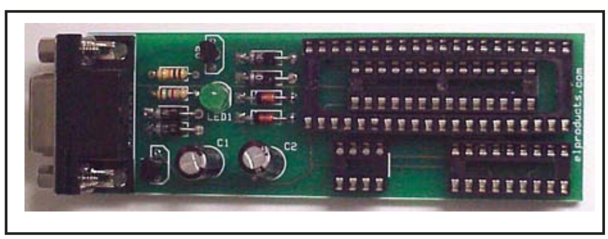
The schematic is shown in Figure 3 and is quite simple. I used a 4 MHz resonator since I didn't need a lot of speed. A 1K ohm resistor is used as the MCLR pull-up and I used one of my breadboard power adapter modules for the 5V supply. This makes it easy to jumper voltage and ground to the circuit as the breadboard rails have the power running through them from the power adapter module.

The LEDs are tied to Port B pins through 220Ω resistors and spread out on the breadboard so they can line up with a plastic tray. The "Y" probes are connected to ground on one side and a pull-up resistor on the other side that is connected to the five-volt rail. I sized this pull-up to match the resistors I knew were in the batch but this could easily be a potentiometer for multiple resistor ranges; you would have to tune it to the proper value before testing any resistors.



⇒ FIGURE 2. The full setup.

The point where the "resistor under test" and the pull-up resistor meet are connected to the A0 pin A/D port. This is a pretty easy schematic to build and using a breadboard didn't require me to fire up



⇒ FIGURE 4. JDM style programmer.

the soldering iron.

I programmed the PIC using my simple JDM style programmer shown in Figure 4. I introduced it in my last column and offer it through my website **elproducts.com** This little programmer running off the ic-prog.exe freeware software really works great.

SOFTWARE

The software is written in PICBasic Pro, which makes using the A/D port very easy. PICBasic Pro has an ADCIN command that handles all the register setup and places the result in a variable you designate in the command line. Let's step through the code to see how it works. The full code is shown in the Software Listing, which is available on the *Nuts & Volts* website (**www.nutsvolts.com**).

The description at the top of the program is preceded by single quotes which indicates to PICBasic Pro the line is a comment and not a command.

The program code really begins after the comments as the PICBasic Pro DEFINEs are established for the A/D converter. These DEFINEs really set up the PIC's internal ADCON1 register. The analog-to-digital (A/D) converter is set up for a 10 bit result, using the PIC's internal resistor-capacitor sample timer at a sampling delay time of 50 microseconds before starting the A/D conversion.

The variable that will store the 10 bit result needs to be set up as a word and we do that in the line shown here.

```
adval  var    word          ' Create adval to store result
```

Now the ports are initialized by writing directly to the data direction TRIS registers to set them up properly as inputs (1) or outputs (0).

The LEDs connected to Port B are then tested by turning all of Port B high then low with a one second delay in-between.

The Main loop of code is next and this is where all the resistor checking is done. After the label "loop:" the ADCIN command is issued to start the A/D conversion process at the A0 pin and store the 10-bit result (as set up earlier) in the variable "adval."

The value of the "adval" variable is then tested to see which LED to light. Since we know the resistors being checked, each If-Then statement below looks for the range the "adval" must be within. If it matches, Port B is set up to turn off all the LEDs except the proper one that indicates which tray to put the resistor in.

If the resistance measured is greater than 1,000 A/D counts, then all the LEDs are turned off. This is how we keep the LEDs off when no resistor is in the probes.

Finally, the program delays for half of a second and then tests the resistance again by using the GOTO command to jump to the "loop:" label.

I wanted to explain the A/D counts in a little more detail before the software explanation. You see an A/D port measures voltage, not resistance. Therefore, I created a resistive ladder using the 10K pull-up and the resistor under test as the pull-down. The creates a voltage between 0–5 volts, depending on the resistor under test.

The mathematical formula used to come up with the A/D counts (0-1,024) is below:

5V * [Rtest / (Rtest + 10K)] *
[1024/Vref] = A/D counts

In this setup, Vref comes from the internal PIC 5V line so the equation reduces to the formula:

[Rtest / (Rtest + 10K)] * 1024 =
A/D counts

If the resistor under test is very large, then the A/D count will be close to 1,024. If the resistor is very small then, the A/D count will be close to zero. I calculated the A/D for each resistor I knew would be tested and created a range around it. For example, look at the calculation below for the 2K resistor.

[2K/(2K+10K)] * 1024 =
170 A/D counts

To allow for tolerance variation from resistor to resistor, I made the If-Then command range 150 to 200 A/D. If the value of "adval" is between these values, then the second LED is lit indicating that tray is where the resistor belongs.

NEXT STEPS

Obviously, I did not design it for resistors other than the ones I planned to see. If a 1K resistor somehow found its way on to the probes, none of the ranges would match and no LEDs would light up. This would look like it's not working so she would just put it in a scrap pile for me to go through later. The probes were a little touchy so sometimes the lit LED would jump back and forth between two values but eventually settle down at the proper one. Spring clips would probably work better for probes.

CONCLUSION

This project shows just how handy being able to program a PIC can be. You can design custom test equipment or custom control modules with very little effort using a higher level language and a few simple software and hardware tools. Hopefully, you found this article interesting. Let me know what you think and maybe suggest a few ideas you would like me to tackle in a future article. Just email me at chuck@elproducts.com or visit my website's forum under the "Forum" link at **www.elproducts.com** **NV**

To view or download the complete Software Listing, please go to the *Nuts & Volts* website at www.nutsvolts.com

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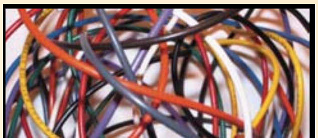

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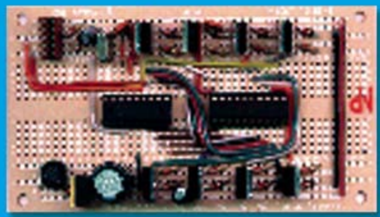

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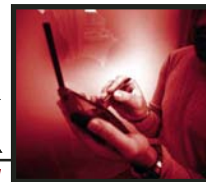


READER FEEDBACK

Continued from page 31

OFF TO A GOOD START

I wanted to drop you a quick note to tell you that I found the January '06 issue to be particularly good. As a long-time 'dabbler' in electronics, I found a number of articles in that issue that were very interesting. The "Perceptron" circuit, the "Getting Started with PICs" article, and the article on analog synthesizers were all great, particularly because of their emphasis on the basics of these technologies. While I know you have a strong following of serious hobbyists and professionals in the area of electronics, please always remember that there is also an audience out here who like to learn and play from a more introductory or intermediate level.

Thanks again for a great issue.

Jim Edwards
Round Rock, TX

FRUSTRATED WITH FORMAT

In reference to "Reader Feedback" "Format Folly" Dec. issue, I fully agree with Len Taddei. The new format is a mess!!! I don't like it!!! The little pictures and things take up half the space. There is no need for it!! You have to try and read around the photos. I don't know where you are going but it is in the wrong direction!! I don't really like your thick paper insert but it is the only one. If you start putting in those cards, then you can count me out as a customer. I have enjoyed *NV* over the years. And, for the record, it's the only magazine I get. Please go back to the old format, before November.

Gary Stutts
Melbourne, FL

PUZZLED BY PERCEIVED PREJUDICE

As a long time subscriber to *Nuts & Volts*, I am puzzled and offended by the misogynist contents of the recent columns from Gerald Fonte.

I did not subscribe to a men's magazine, but to an electronic tinkerer magazine, where I thought prejudice would be kept out of the presentation of circuits and applications, not discussing whether women's supposedly better verbal ability to describe colors is due to an innate superficiality that makes them slaves to fashion and fads. I hope that similar comments about race, national origin, and religion will not also be printed in the future in your publication. They have no place in it either.

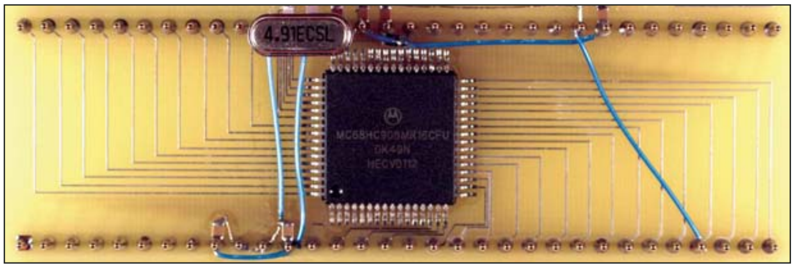
Our nation's economic and intellectual future depends on the motivation of both young women and men. Do not discourage women from buying your magazine by publishing comments clearly conveying the message that women are not motivated in this field because of some innate inferiority. It is untrue, prejudicial and hateful.

Anonymous

■ BY PETER BEST

WEIGHING IN WITH FREESCALE'S 68HC908 MCUs

I LIKE STUFF THAT IS EASY TO USE. I also like easy-to-use stuff that is free. Many of you may have received a free copy of Freescale Semiconductor's CodeWarrior Development Studio for HC08 v5.0 in the mail. If you didn't, fire up your web browser and go to www.freescale.com/cw5 to download your free copy of the CodeWarrior HC08 Development Studio.



■ PHOTO 1. I used 0805 SMT parts and wirewrap wire to fabricate this MC68HC908MR16 MCU module. The pinout grid of the MC68HC908MR16 MCU module is based on a standard 64-pin DIP socket, which allows you to wire an MC68HC908MR16 into breadboard-based projects that aren't based on custom printed circuit boards.

This special edition C compiler includes the CodeWarrior IDE (Integrated Development Environment), a limited code size (16K) C compiler for the HC08 series of microcontrollers, a C source-level debugger, a macro assembler, an assembly-level debugger, Flash programming support, a full-chip simulator, and a Processor Expert development component.

Once you have installed your copy of the CodeWarrior Development Studio for HC08 v5.0, all you have to do is select a suitable HC08 microcontroller, collect some development hardware, and start constructing your HC08 embedded application. If that sounds like fun, read on and I'll show you how to use the CodeWarrior Development Studio to bring an HC08 microcontroller to life from the ground up.

SELECTING AN HC08 MICROCONTROLLER

There are a ton of HC08 microcontroller variants you can choose from. Depending on your application, you can choose from HC08 microcontrollers in eight-pin packages or go heavy duty with a 64-pin TQFP HC08 family member. The good news is that once you know how to write code for a particular HC08 microcontroller, you can write code for all of the HC08 microcontrollers.

Freescale Semiconductor likes to call their microcontrollers MCUs (Microcontroller Units). Every 68HC08 MCU is based on the CPU08 central processor unit, and as I mention earlier, you can get 68HC08 MCUs in a variety of memory sizes and package types. Some HC08 MCUs contain specialized peripheral subsystem modules such as PWM (Pulse Width Modulation) or SCI (Serial Communications Interface) while smaller HC08 MCUs may not support any peripheral subsystems at all. So, rather than trying to cover all of the MCU subsystems by showing you multiple 68HC08 MCUs, I've chosen a particular Freescale Semiconductor HC08 MCU that contains all of the peripheral subsystem goodies you'll most likely use in your own HC08 embedded applications.

Since the free edition of the CodeWarrior Development Studio for HC08 microcontrollers can only compile up to 16K of code, I've chosen the MC68HC908MR16, which contains 16K of in-circuit programmable Flash program memory. The MC68HC908MR16 also houses 768 bytes of on-chip RAM, a six-channel PWM subsystem, SPI and SCI (Serial Communications Interface) communications subsystems, a pair of 16-bit timers, a clock generator module (CGM), and a 10-bit analog-to-digital converter module.

All of the aforementioned subsystems are available to the user via the MC68HC908MR16's 64 pins, and as you may have guessed, the MC68HC908MR16's six 12-bit PWM channels make it an ideal motor controller. Despite the fine-pitch package and the gaggle of I/O pins

and peripheral subsystems, the MC68HC908MR16 is relatively easy to bring up and use. With that, let's begin by building up a custom MC68HC908MR16 MCU module.

ASSEMBLING AN MC68HC908MR16 MCU MODULE

A custom printed circuit board (PCB) would be the way to go if we were designing the MC68HC908MR16 into a dedicated embedded application. However, the object of this column is to introduce you to the MC68HC908MR16 and all of its major peripheral subsystem modules.

Solderless breadboards are ideal experimentation platforms, but the .1-inch grid of a solderless breadboard is not at all friendly with the sub-millimeter pitch of the MC68HC908MR16's pins. One solution to this dilemma is to design a custom PCB for the MCU and make the custom MCU printed circuit board compatible with a solderless breadboard grid. That's exactly what I've done.

The MC68HC908MR16 MCU module you see in Photo 1 is an independent MC68HC908MR16 microcontroller system complete with CPU clock circuitry, reset circuitry, and power rail bypassing that fits into a standard 64-pin DIP socket footprint. Applying +5 VDC to the MC68HC908MR16 module is all we have to do to make it go. And, since the MC68HC908MR16 MCU module pins are on .1-inch centers, it is solderless breadboard friendly.

As you can see from the MC68HC908MR16 schematic, there isn't much needed in the way of external components to clock and reset the MC68HC908MR16. If you're wondering about how I came to select a 4.9152 MHz crystal, it all has to do with baud rates, some easy math, and the MC68HC908MR16's internal PLL (Phase Locked Loop). Let's take a closer look at how I determined the value of filter capacitor C7 and what to put into the MC68HC908MR16's CGM (Clock Generator Module) registers.

The MC68HC908MR16's CGM generates the crystal clock frequency, which is called CGMXCLK. The frequency of CGMXCLK is equal to the frequency of the crystal. The base clock signal, CGMOUT, is also a product of the CGM clock generation process. The MC68HC908MR16's system and peripheral clocks are fed by CGMOUT. CGMOUT is based on either the crystal clock divided by two or the PLL clock divided by two. The PLL clock is called CGMVCLK.

The maximum bus frequency that can be safely dialed into the MC68HC908MR16's clocking scheme is 8 MHz. The MC68HC908MR16's bus frequency is defined as CGMOUT divided by 4 as the CGMOUT signal, which is the CGMXCLK frequency divided by 2, is divided by 2 again after it reaches the SIM (System Integration Module). The SIM distributes the clock signals to the various MCU subsystems.

Let's say that you want to run the MC68HC908MR16 bus at 8 MHz. The maximum crystal frequency allowed across the MC68HC908MR16's OSC1 and OSC2 pins is 8 MHz, which means you can't drive the MC68HC908MR16's crystal oscillator with a 32 MHz crystal. So, you would be forced to connect a 32 MHz oscillator module to the MC68HC908MR16's OSC1 pin to achieve the 8 MHz bus frequency.

An 8 MHz bus frequency is great if all you want is speed. However, what if you wanted to drive the MC68HC908MR16's SCI baud rate generator to produce a reliable serial baud rate of 115200 bps? If you do the math, you'll find that the 115200 baud rate error percentage with an 8 MHz bus clock is a little less than 8%. Driving the MC68HC908MR16's bus at 7.3728 MHz will produce a rock-solid baud rate of 115200 bps from the MC68HC908MR16's SCI baud rate generator with 0% error.

A little high school math tells us that the crystal frequency to achieve the 7.3728 MHz bus frequency will be 29.4912 MHz (4 * 7.3728 MHz), which is again too high for a crystal to drive the MC68HC908MR16's crystal oscillator. Even though the oscillators are good clocking solutions in some cases, a more flexible and cost effective solution can be achieved by using the MC68HC908MR16's PLL and a cheaper, lower frequency crystal.

The MC68HC908MR16's PLL is composed of a VCO (Voltage Controlled Oscillator), a modulo VCO frequency divider, a phase detector, a loop filter, and a lock detector. The operating range of the MC68HC908MR16's PLL VCO is approximately one-half to twice the center-of-range frequency. The frequency of the VCO is changed by modulating the voltage on the CGMXFC pin, which attaches to the C7 filter capacitor I mentioned earlier. The nominal VCO center-of-range frequency is equal to 4.9152 MHz. DING!

Now that you know where my crystal frequency value came from, let's put a pencil to the PLL calculations. To run as fast as possible and

■ PHOTO 2. The Cyclone PRO is able to debug and program Freescale Semiconductor 68HC908 targets in-circuit via the Monitor ROM (MON08 Port). This amazing box can communicate with a PC through either RS-232, Ethernet, or USB interfaces. Don't want a PC in the mix — the Cyclone PRO can be configured to function as a stand-alone programmer and program target HC08 devices independent of a PC. The neatest feature of the Cyclone Pro is its ease of use.

produce an accurate baud rate clock, let's use the value of 7.3728 MHz for our desired bus clock frequency and name the value f_{BUSDES}. We know that our bus clock frequency is derived from a higher frequency clock that is four times the value of the resultant bus clock. So, since we will be getting our clock from the PLL — the desired VCO frequency — which we will call $f_{VCLKDES}$, will equal to 4 x 7.3728 MHz, or 29.4912 MHz. A buffered reference clock of 4.9152 MHz taken directly from the output of the crystal oscillator, which we will call f_{RCLK}, is fed into the phase detector and lock detector of the PLL. Okay, we have 4.9152 MHz coming into our PLL and we want 29.4912 MHz out.

So, we must calculate a VCO frequency multiplier value. We do that by dividing $f_{VCLKDES}$ by f_{RCLK}, which yields 6.00. In our case, our desired VCO clock frequency ($f_{VCLKDES}$) is actually equal to our actual VCO output frequency. To calculate the VCO linear range multiplier (L), all we have to do is divide our actual VCO output frequency by the nominal enter-of-range frequency (29.4912 MHz / 4.9152 MHz), which also yields the value of 6.00.

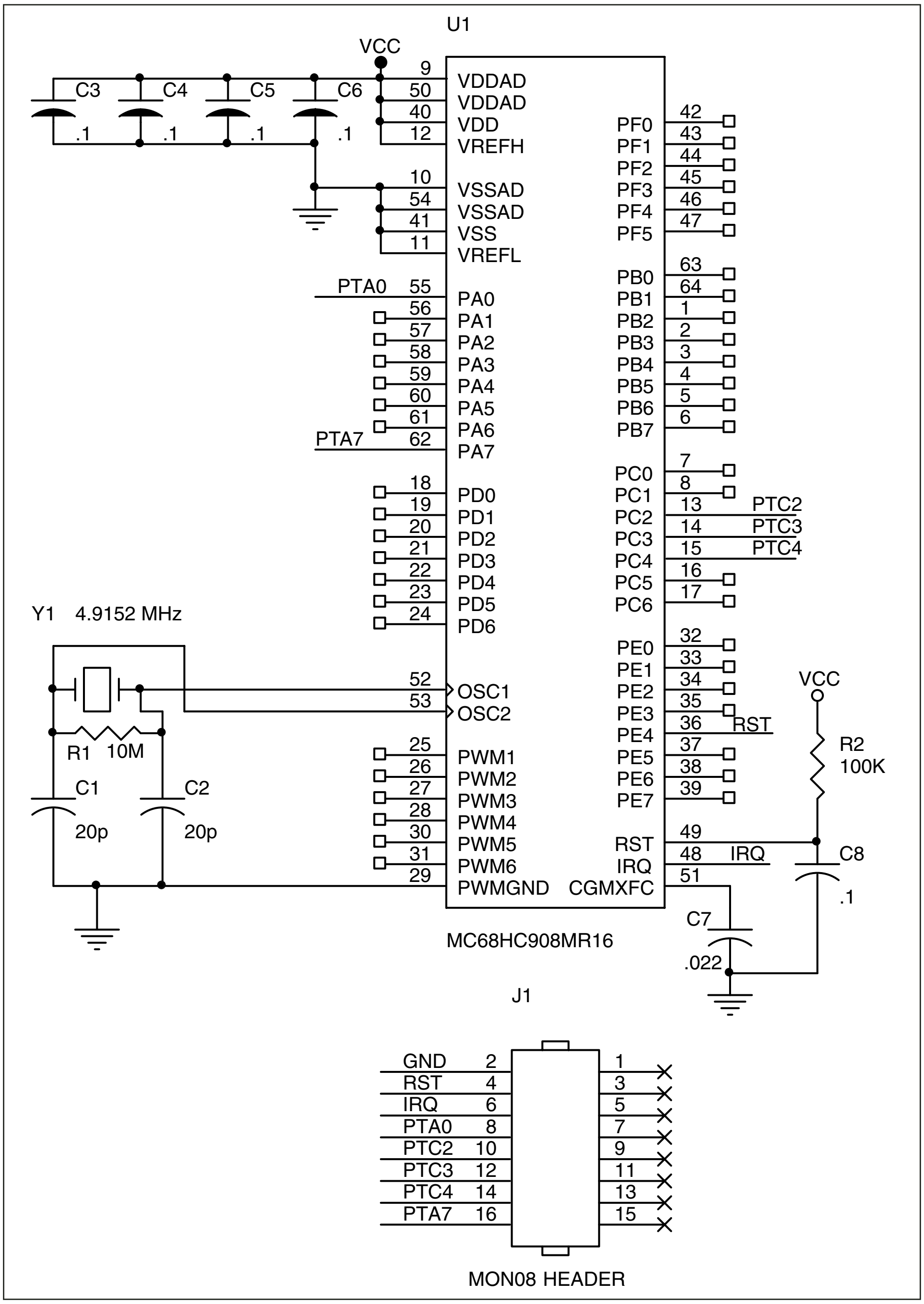
So far, so good. We have — at least on paper — achieved our desired bus frequency without exceeding the maximum operational frequency limits (32.8 MHz) of the VCO. Now all that's left to do is to write our calculated VCO frequency multiplier and VCO linear range multiplier values into the PLL programming register (PPG). The VCO frequency multiplier value (0x06) goes in the upper nibble PPG and the VCO linear range multiplier value (0x06) is placed into the lower nibble of the PPG.

Calculation of the filter capacitor on the CGMXFC pin is relatively easy. The formula is C_{FACT} * (V_{DDA} / f_{RCLK}). The filter capacitor multiply factor constant C_{FACT} is defined in the MC68HC908MR16 datasheet as .0154. V_{DDA} is +5VDC and we know from the previous text that f_{RCLK} is known to be 4.9152 MHz. Substitute those values into the equation and you'll come up with 0.0156. The nearest standard capacitor value is 0.022µF. That's all there is to it.

A BIT OF HARDWARE SYSTEM INTEGRATION

Now that I have some good start-up values for the MC68HC908MR16's CGM, the MC68HC908MR16 MCU module is ready to be attached to a debugger and tested. My favorite HC08 programmer/debugger is P&E Micros' Cyclone Pro, which you see in Photo 2.

The Cyclone Pro does it all as far as the HC08 is concerned. Using the Cyclone Pro, I can erase, program, and verify an HC08 device in-circuit. In addition, the Cyclone Pro gives me a full view of what's going on inside the MCU. The Cyclone Pro automatically controls all aspects of putting the target MCU into monitor mode including cycling the power to the target MCU and associated



■ SCHEMATIC 1. A dozen off-the-shelf external components and the MC68HC908MR16 is ready for action.

circuitry. Integrating the Cyclone Pro into my MC68HC908MR16 system was a snap. I downloaded the latest Cyclone Pro installation files and firmware from the P&E website. After running the Cyclone Pro install program, my Cyclone Pro was identified via USB and the latest firmware update was automatically downloaded to my newly found Cyclone Pro.

The next step in incorporating my Cyclone Pro involved wiring in and attaching the Cyclone Pro's MON08 (Monitor ROM) header to the MC68HC908MR16 MCU module. The MON08 pinout you see in the MC68HC908MR16 MCU module schematic (Schematic 1) was pulled from the pages of the Cyclone Pro User Manual.

Once I had finished wiring in the MON08 header, I wired the MC68HC908MR16 MCU module into the solderless breadboard power grid and attached the solderless breadboard's bulk positive and ground power connectors to the target power output connector on the Cyclone Pro. I used a +5VDC switcher wall wart to power the MC68HC908MR16 MCU module with the output of the switcher power supply going to the Cyclone Pro's target input power connector.

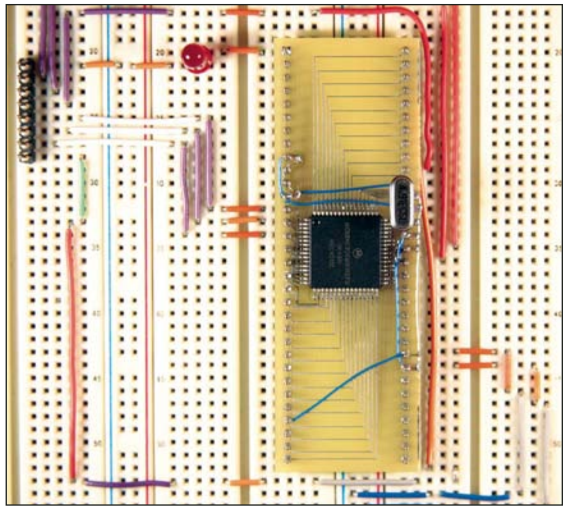
The Cyclone Pro's target input power connector is connected to the Cyclone Pro's target output power connector center-to-center and outer-shell-to-outer-shell via electro-mechanical relay contacts. The Cyclone Pro cycles the target power and effects power-on resets via its internal relay.

The connections to the MC68HC908MR16 MCU module you see in Photo 3 are minimal at this point with only power and the Cyclone Pro MON08 interface being attached to the MCU module. It's time to fire up the CodeWarrior Development Studio IDE and write some simple code to see if we can actually use the Cyclone Pro to talk to the MC68HC908MR16 hardware.

A BIT OF FIRMWARE SYSTEM INTEGRATION

Take a look at the screenshot in Photo 4. Do the values look familiar? They should because you just calculated them not too long ago. Photo 4 is a look into the CPU Bean. Beans are actually logical entities used to describe the functionality of the various MC68HC908MR16 subsystem modules and components of subsystem modules such as I/O port pins.

For instance, in the Bean shown in Photo 4, we are establishing the frequency of the crystal oscillator and calculating the PPG values needed to run our MC68HC908MR16 MCU at a bus frequency of 7.3728 MHz. Also, notice that I've disabled the maskable CPU interrupts in this Bean. The CodeWarrior IDE Beans can also be configured to generate code. I'll use the BitIO Bean to help me toggle an LED I'll place on bit 2 of Port B. Let's move on and talk about how I generated the LED

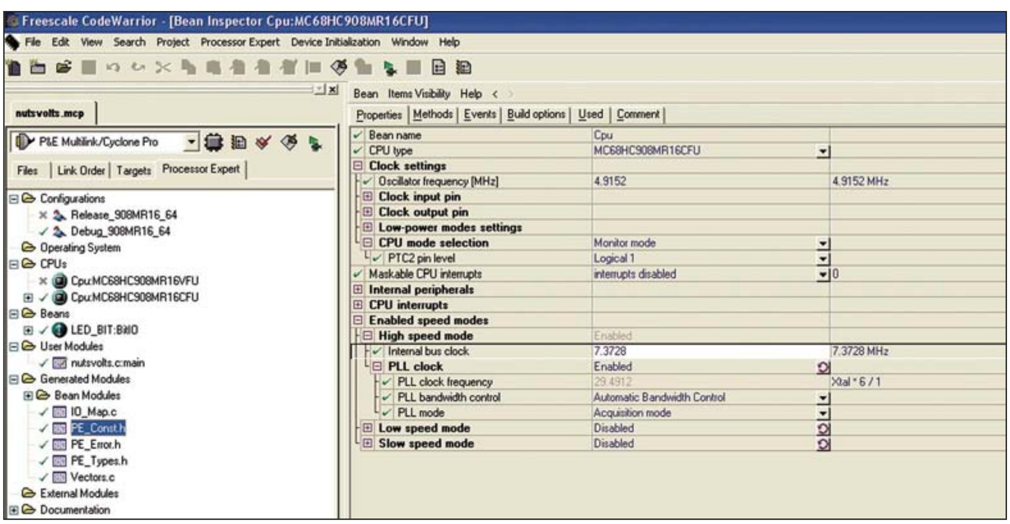


■ PHOTO 3. Using a solderless breadboard makes for quick and easy circuit changes and additions. The MC68HC908MR16 MCU module attaches to the solderless breadboard grid just like an IC in a DIP configuration would.

blinker firmware.

I began by creating a new project, which entailed telling the CodeWarrior IDE which MCU and debugging/programming hardware system I wished to use. Of course, I selected the MC68HC908MR16 and the P&E Cyclone Pro, respectively. I chose to invoke the Processor Expert and was then presented with a Bean Selector window and a really pretty picture of an MC68HC908MR16VFU.

I accessed the CPU Bean (the Bean you see in Photo 4) with the Bean Inspector and proceeded to change the CPU type to match the microcontroller on my MCU module



■ PHOTO 4. This is a shot of the CodeWarrior IDE's Bean Inspector. The Bean Inspector actually helped me to set up the PLL correctly by informing me of errors I made while inputting my frequency parameters. Beans aren't absolutely necessary, but they can relieve some of the coding pain if you decide to use them in your project.

(MC68HC908MR16CFU) and set the parameters for the PLL. I then performed a compile and link (called a make by the IDE) operation, which generated a Cpu.c startup source file and a skeleton nutsvolts.c application source file. Various other .c and .h support files were also generated.

At this point, I decided that everything looked okay. So, I once again used the Bean Selector and accessed the Port I/O area of the CPU Internal Peripherals folder. I double-clicked on the BitIO Bean to add it to my project. Then, using the Bean Inspector, I named the newly included BitIO Bean LED_BIT. Since I only want to make sure I can compile, link, load, and debug the project code, I went with the LED_BIT Bean's default I/O pin setting of PB2, which happens to be pin 1 of the MC68HC908MR16.

In the *Methods* area of the LED_BIT Bean, I told the Bean to only generate code to set and clear the Port B I/O pin. I then recompiled the project, which brought in the new LED_BIT Bean and its associated code. As you can see in Listing 1 (Listing 1 is available at the *Nuts & Volts* website; **www.nutsvolts.com**), I added my LED blinker code to the nutsvolts.c application source file, which uses the LED_BIT *LED_BIT_ClrVal and LED_BIT_SetVal* macros and a homebrew for-loop delay routine. Everything compiled and linked just fine. I cheerfully clicked on the CodeWarrior IDE's Debug icon.

UH OH

The Cyclone Pro drivers loaded and the Cyclone Pro contacted and identified the MC68HC908MR16 MCU that was planted on the solderless breadboard. According to the various popup messages, the MC68HC908MR16 erased and programmed successfully. However, the program didn't seem to be running and the LED was not blinking. I rechecked my MCU module wiring and traced out all of the solderless breadboard connections. I even swapped in a new 4.9152 MHz crystal.

The stupid thing still would not run. I was at the point of building up another MC68HC908MR16 MCU module. However, I decided to debug the code to see if everything was working as designed. From experience, I know that even the simplest of LED blinker code can harbor a nasty eat-you-alive bug.

After single stepping through the Cpu.c code you see in Listing 2 (Listing 2 is also available at the *Nuts & Volts* website.), I noticed that the program was hanging while waiting for the PLL to lock. So, I commented out the *while (!PBWC_LOCK)* statement and its associated braces and recompiled the project. The LED blinked as it should have after reloading the MC68HC908MR16 with the new code sans the PBWC_LOCK statement.

This was good and bad.

The LED was blinking because the CPU was being clocked. However, since the PLL never locked, the PLL clock was probably not running the bus at the desired 7.3728 MHz. This is great for randomly blinking LEDs but bad for functions and peripherals that require a stable and accurate timing source.

It took me several hours to find the problem. Do you see the very obvious cause of the problem in Listing 2? (A little Jeopary music goes here.) The comment regarding the value of the PPG register is correct but the actual value in the code and the comment that precedes the PPG register load instruction are bogus. The PLL never locked because PPG was loaded with 0x1E instead of 0x66, which we calculated by hand earlier. I edited the code in Listing 2, changing the *setReg8(PPG,0x1E)* instruction to *setReg8(PPG,0x66)* and recompiled. Upon running the Cyclone Pro debug session, the PLL code was executed indicating that the PLL successfully locked and the little snippet of LED blinker code didn't hang and performed just as I expected it to.

THE FUN HAS JUST BEGUN

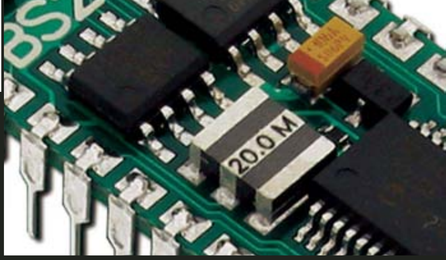
Okay, the MC68HC908MR16 MCU module is functional and we have identified and squashed a bug inherent to the CodeWarrior Processor Expert code generator. Hey, the CodeWarrior code is free. So, I can't really complain. Hopefully, that little bug will be fixed in an upcoming patch or maintenance release.

We still have all of the MC68HC908MR16 peripheral subsystems to explore and that's exactly what we're going to do next month. There's also more I need to tell you about CodeWarrior Development Studio for HC08 v5.0. In the meantime, for those of you that wish to build your own MC68HC908MR16 MCU module, I'll make an inexpensive MC68HC908MR16 MCU module parts kit available to you on the EDTP Electronics website at **www.edtp.com** Be sure to check in on my progress next time as I'll continue to show you how to include the HC08 series of Freescale microcontrollers in your Design Cycle. **NV**

SOURCES:

■ Peter Best can be reached via email at the following address: **peterbest@cfl.rr.com**

■ A complete kit of parts, which includes a printed circuit board with a mounted MC68HC908MR16 MCU, can be purchased from EDTP Electronics, Inc. (**www.edtp.com**).



STAMP APPLICATIONS

PUTTING THE SPOTLIGHT ON BASIC STAMP PROJECTS, HINTS & TIPS

■ BY JON WILLIAMS

LIGHTS, BASIC STAMP, ACTION!

HAVING BEEN RAISED IN THE DESERT OF SOUTHERN CALIFORNIA, I'm pretty much a warm weather person. The fact is, I don't like the winter months — not at all, nothing about them. Okay, except for one thing — holiday lights. The coolest thing about the Christmas season is the lights. I know what you're thinking: "Hey pal, that was two months ago." True, but we can do lighting any time of year — and not just for holiday displays. In fact, my own interest in lighting control started when I was 18 and working with a friend's rock-n-roll band. With the crush of the holiday season behind us, let's have a look at lighting control and strategies for getting the most from our code. Who knows, we just might come up with a way to light up our Valentine's life ...

Those that haven't tried it may think controlling a 120 VAC lamp is trivial — we do it all the time, right, we just flip a switch? But doing that with a microcontroller is a little more involved. The first thing that comes to mind is a relay, which works, but presents its own challenges. Challenge number one is that we usually need some sort of buffer (e.g., a ULN2803) between the microcontroller and the relay, and two, contact arcing can become a serious issue, especially when it leads to contact fusing. And, mechanical relays are just plain noisy. Who needs all that clickity-clack nonsense? I don't ... do you?

Okay, then, what to do? Use a relay, of course; a *solid state relay*. A solid state relay (SSR) isn't actually a relay, it's a special circuit that [usually] takes a low-voltage, low-current input and switches a high-voltage AC or DC output — with optical isolation between the input and output sides. The great thing about SSRs is that we can easily find units that will connect directly to the BASIC Stamp and switch 120 VAC outputs. A popular SSR is the Crydom D2W series, like the one shown in Figure 1 (in my hand for scale). It draws just a few milliamps at five volts on the input side.

Just before the last holiday season, the Parallax EFX group released the RC-4 relay board that is designed to hold up to four Crydom D2W (and compatible) SSRs. The RC-4 takes a TTL serial command input and will activate the relays accordingly. The RC-4 is addressable so up to four boards (a total of 16 control outputs) are available on a single BASIC Stamp I/O pin. And, it has a baud setting jumper that allows it to work with the BS1 at 2400 baud, or with the BS2-family at 38.4 kBaud.

The RC-4 became quite popular with holiday decorators this past season, though some stumbled over using more than one in a single application. It's really pretty easy, and PBASIC2 gives us the ability to treat our control outputs (up to 16) as a single [Word] variable; we'll see how in a just a moment. And, by taking advantage of conditional compilation, we can structure our lighting control program such that it can be configured to run on the Stamp CI board and use Opto-22 SSRs for the outputs. These products are widely used in industrial applications, and provide additional features like fuse-protected, high-voltage outputs.

■ FIGURE 1. Crydom SSR.

GETTING CONDITIONAL

In the past, we've typically used conditional compilation to set program constants based on the BASIC Stamp module in use. We'll do

This article deals with products that can switch 120 VAC which, if mishandled, can be dangerous and even lethal. Your safety is in your own hands; if you have any doubts about working with 120 VAC circuits, it is strongly suggested that you seek assistance from a qualified electrician.

that again, but we're also going to add a custom program switch so that we can decide on serial output for a network of RC-4 boards, or parallel output when using the program with a Stamp CI board and Opto-22 relays.

Let's start at the very top. Using **#DEFINE**, we can create a conditional symbol that will affect other parts of the program.

```
#DEFINE __SerialMode = 1

#IF __SerialMode #THEN
  Sio             PIN     15
#ELSE
  Lights          VAR     OUTS
#ENDIF

Speed           PIN     14
PgmSelect       PIN     12
```

In order to keep conditional symbols straight in my own head, I've decided to preface them with two underscore characters. As you can see, the first place we use the **__SerialMode** symbol is to define our output structure. An important thing to remember is that the only parts of the program that get compiled and downloaded are those that satisfy the conditional statement. In the code above, for example, the program doesn't ever know about the symbol called **Lights** because the setting of **__SerialMode** excludes it from compilation. Of course, if we want to switch to parallel mode (for use with the Stamp CI board), we would change the value of **__SerialMode** to zero.

There are two I/O pins common to both modes: one selects the output sequence (we're keeping this very simple with just two sequences), and the second is used to read a potentiometer with **RCTIME** so that we can control step speed when the program is running.

Moving into the body of the program we will use **__SerialMode** again, this time to set pins P0-P11 to outputs when we're configured for parallel mode:

```
Reset:
  #IF (__SerialMode = 0) #THEN
    DIRS = $0FFF
  #ENDIF
  lightVal = $0000
  GOSUB Update_Outputs
```

In either case, the state of the light outputs (in *lightVal*) is cleared and the **Update_Outputs** subroutine is called to initialize this state:

```
Update_Outputs:
  #IF __SerialMode #THEN
    SEROUT Sio, Baud, ["!RC4", %00, "S", lightVal.NIB0,
                       "!RC4", %01, "S", lightVal.NIB1,
                       "!RC4", %10, "S", lightVal.NIB2]
  #ELSE
    Lights = lightVal & $0FFF
  #ENDIF
  RETURN
```

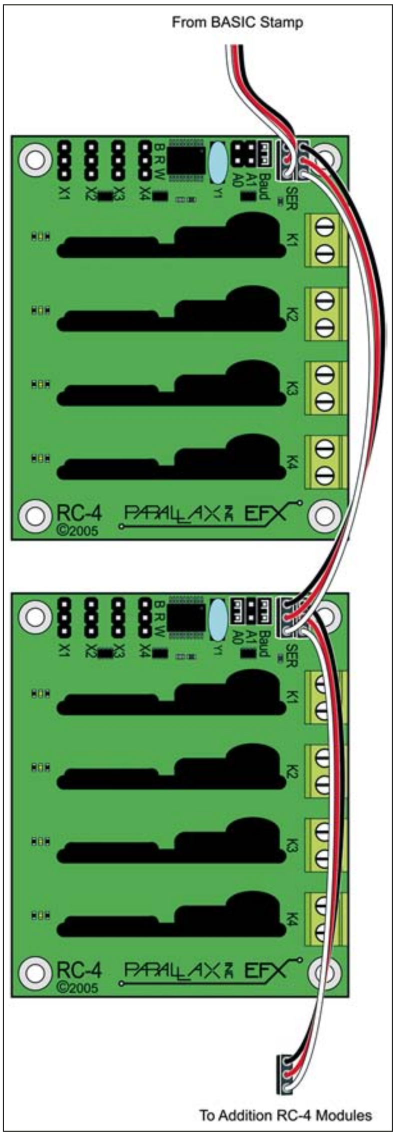
And here's where we really get to the point of using **__SerialMode** as it directs the value of *lightVal* to the appropriate destination. This is a really good demonstration of the power and flexibility of PBASIC2. Since each RC-4 has four outputs (conveniently, the size of a nibble), we are able to use the NIB variable modifier to select the appropriate bits (used by the RC-4's Set command) for each board.

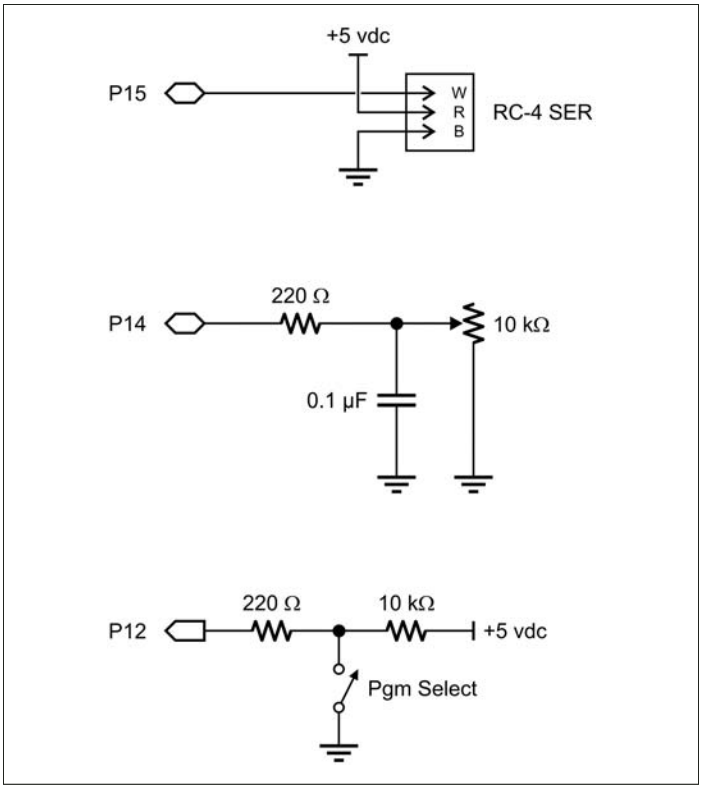
You may be wondering if this will work as we've squeezed three output commands into a single **SEROUT** statement. Yes, it does work. The reason it does is that each RC-4 is waiting for the "!RC4" header and its own board address. If the board address is wrong, that RC-4 will go right back to waiting for the header (for those who are also interested in programming the SX with SX/B, the RC-4 control code is written entirely in SX/B with the same techniques we used last month with the PSX helper). By putting all three commands into a single **SEROUT** statement, the program runs a little quicker (because we don't have to reload and configure additional **SEROUT** statements) — this will be important when we're running quick steps.

Just a couple tips on the RC-4: It actually gets its power from the serial line, so if you're going to connect it to a BOE servo header, you must make sure the servo power jumper is set to Vdd (+5 VDC). On the RC-4, you'll see two headers marked SER. This allows the RC-4 to be daisy-chained as shown in Figure 2. Note that the Baud jumper is inserted for 38.4K when using the BS2-family. If you're going to connect the RC-4 to a Prop-1, remove the Baud jumper for 2400 baud operation.

As you can see in Figure 2, each RC-4 has two jumpers, A0 and A1, that allow the board to have a unique address (%00 to %11). When a jumper is inserted, that address bit is set to one; removed clears the bit to zero. In Figure 2, the top RC-4 is set to address %00 (both jumpers removed) and the lower board set to %01 (A0 in, A1 out). The other nice thing about the RC-4 is that it conforms to the Parallax AppMod protocol, so you can put it

■ FIGURE 2. RC-4 Networking.





■ FIGURE 3. Lighting Control Schematic.

on the same serial line as other serial devices, such as the Parallax Servo Controller (PSC).

Let's get back to running our light program. The sequences are stored in **DATA** statements like this:

```
Zig            DATA    Word %000000000001
               DATA    Word %000000000010
               DATA    Word %000000000100
               DATA    Word %000000001000
               DATA    Word %000000010000
               DATA    Word %000000100000
               DATA    Word %000001000000
               DATA    Word %000010000000
               DATA    Word %000100000000
               DATA    Word %001000000000
               DATA    Word %010000000000
               DATA    Word %100000000000

Wash           DATA    Word %000000000000
               DATA    Word %000001100000
               DATA    Word %000011110000
               DATA    Word %000111111000
               DATA    Word %001111111100
               DATA    Word %011111111110
               DATA    Word %111111111111

EndOfPgms      DATA    0

Pgm0Len        CON     Wash - Zig
Pgm1Len        CON     EndOfPgms - Wash
```

Note the constant definitions that follow the **DATA** statements. These work because when the program gets compiled, the symbols **Zig**, **Wash**, and **EndOfPgms** are actually converted to numeric values (the address of that location in EEPROM). With a little math, we're able to determine the length of the sequences so that our program knows when to start over — and with this technique we can change the sequence length without any additional edits to our core code. Note, too, that we've used the Word modifier with **DATA** so each step is actually using two bytes of EEPROM; we'll need to account for this later.

And now for the main loop of the program. Its purpose is to read the step values from the selected sequence and send them to the designated outputs as we've already discussed.

```
Main:
  DO
    LOOKUP PgmSelect, [Zig, Wash], baseAddr
    READ baseAddr + pgmStep, Word lightVal
    GOSUB Update_Outputs
    GOSUB Speed_Delay
    LOOKUP PgmSelect, [Pgm0Len, Pgm1Len], pgmMax
    pgmStep = pgmStep + 2 // pgmMax
  LOOP
  END
```

At the top of the loop, we start by checking the sequence selection by using the value of **PgmSelect** (input P12) to control a **LOOKUP** table. If you want to extend to four sequences, it's pretty simple: just add another switch to P13 and change that **LOOKUP** line to something like this:

```
    LOOKUP (IND & %11), [Zig, Zag, Wash, Wear], baseAddr
```

The purpose of the **LOOKUP** line is to get the base (starting) address of the sequence that is currently selected. By doing this at the top of the loop, we can change the sequence at any time. With the base address in hand, we read the selected **DATA** table for the current step value and move that into the variable *lightVal*, and then the target output structured is updated as we went through earlier.

The next line calls a subroutine called **Speed_Delay** that allows us to control the speed of the sequence with a potentiometer (see Figure 3 for the schematic). I get a lot of mail on this subject, so let me go through this in a little more detail so that you can add external speed controls to your programs.

While developing the program, I started with this:

```
Speed_Delay:
  HIGH Speed
  PAUSE 1
  RCTIME Speed, 1, delay
  delay = delay */ Adjust
  RETURN
```

This subroutine will read the pot with **RCTIME** and scale the value (using the conditional constant, **Adjust**) for the BASIC Stamp module in use. Remember, **RCTIME** is really just a type of stopwatch that measures the charge or discharge time of a capacitor. Each module has its own internal timing units, so using **Adjust** lets us end up with the same return value, regardless of which BASIC Stamp module we put to use. The value of **Adjust** is set in a **#SELECT-#CASE** structure that also sets the serial baud

■ FIGURE 5. Parallax Neon Sign.

rate parameters for use with the RC-4 network.

Now we can use **DEBUG** to see what we get from the **RCTIME** circuit on the extreme ends of the potentiometer. On my system, I got 18 on the low end, and 1,124 on the high end. What we would like to do is rescale this range to 50 to 1,000 milliseconds for our step delay. Here's the process:

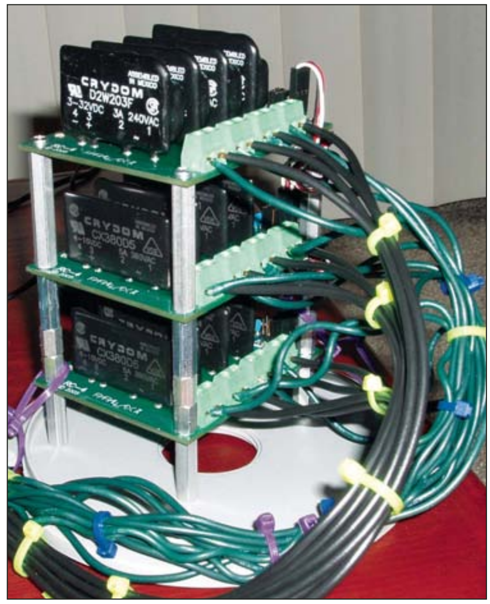
The span of our raw input is 1,106 (1,124 minus 18). We divide this span into our desired output span of 950 (1,000 minus 50) and end up with 0.858. You'll remember that we've used the ** operator in the past to multiply by fractional values of less that one, so that's what we'll do here. To convert 0.858 for use with **, we multiply the fraction by 65,536. The last part is to compensate for the low end of the output range (the "b" in the *mx + b* equation). After the multiplication, we add 35. Where did this come from? Since the low-end raw input is 18 and gets multiplied by 0.858, it will be reduced to 15. Our minimum new output value of 50 minus 15 is 35. **DEBUG** can be used to confirm our new range is very close to 50 to 1,000. Knowing how we worked through the process, you can now readjust the program to create any minimum-to-maximum speed delay that you like.

An important lesson here is that there will be times when we have to work through a program empirically to get to the final result. Here's what we end up with:

```
Speed_Delay:
  HIGH Speed
  PAUSE 1
  RCTIME Speed, 1, delay
  delay = delay */ Adjust
  delay = delay ** $DBE4 + 35
  PAUSE delay
  RETURN
```

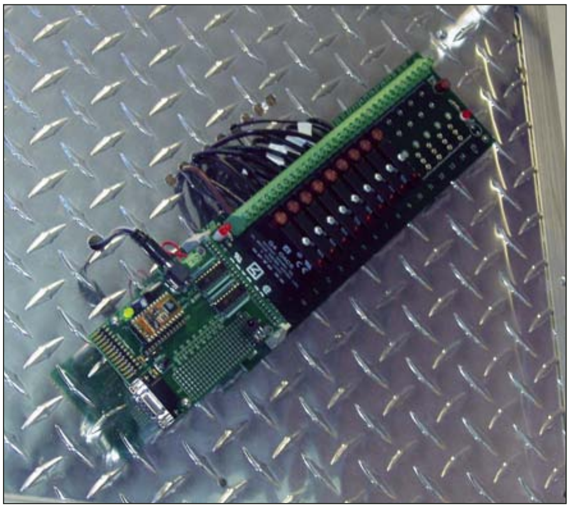
Getting back to the main code we're left with pointing to the next program step. Again, **LOOKUP** is used to determine which sequence is selected and assign the value of *pgmMax* (length of sequence in bytes). The next requirement is to add two to *pgmStep* — we have to do this because we're using Word-sized step values. The modulus operator takes care of wrapping the sequence back to its beginning.

And there we have it: a simple lighting control program that can send its output to a network of RC-4 relay boards or to Opto-22 SSRs using the Stamp CI board. I think this demonstrates the extraordinary flexibility of PBASIC2, especially when we use conditional compilation strategies. Okay, now how will you use this project to light up your Valentine's day?



■ FIGURE 4. Tower of Power.

And just to show that we at Parallax actually put all this stuff to use, have a look at Figures 4 through 6. Figure 4 is Ryan Clarke's (Parallax Tech Support) RC-4 "Tower of Power" that he used to control a lighting sequence for his Christmas tree (it was a pretty fancy tree!). Figures 5 and 6 show a custom neon sign that my boss, Ken Gracey, and I



■ FIGURE 6. Stamp CI Board.

built for trade shows. The neon part was, of course, contracted out to a sign shop. We took care of the control by using a BS2p on a Stamp CI board and a set of Opto-22 relays. If you happen to visit our Rocklin, CA office, be sure to pop into the "Purple Room" for a look at the sign. It uses a pretty sophisticated program that includes IR remote control of the sequence and step speed.

One final note if you do use this program/circuit on the Stamp CI board (like we did with the neon sign): You need to cut the traces that connect P12-P14 to the output buffer. This will prevent the buffer circuitry from interfering with sequence selection and the RCTIME circuit.

HACKER'S HINT

If you're into hacking store-bought products to make them your own, and you like weird and wacky items, you may want to be on the lookout for the various "talking" animals (fish, deer heads, etc.) that have become popular at large discount stores. The Parallax EFX gang (John Barrowman, Ryan Clarke, and me) bought a talking deer head (about $100), gutted the electronics, and then installed a Prop-1 controller and an AP-8 audio player. It took about 15 minutes to determine which motor did what (all run at nine volts DC, and we used the supply that came with the head to power the Prop-1 and AP-8). So, if you want to have fun with your friends and family, pop your own voice into an AP-8 and let your favorite animal deliver the message!

Happy Valentine's Day to all of you that are romantically inclined, and to all, Happy Stamping until we meet again next month! In April, we'll be talking about a new Parallax controller that is so powerful it will make your head spin! **NV**

RESOURCES

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BY GERARD FONTE

INSTRUMENTATION

INSTRUMENTATION, SOMETIMES CALLED TEST AND MEASUREMENT, is a vital component of engineering and production. This month, we'll examine instrumentation fundamentals and look at a couple of examples. We'll also discuss some practical aspects that may help you during the design and development of your product.

WHAT AN INSTRUMENT IS

Any and all instruments do exactly one of three things. They generate a signal, measure a signal, or generate and measure a signal together. They are always used to gather information about something. Instruments that generate signals usually, but not always, have "generator" as part of their names. There's the RF signal generator, audio generator, digital pattern generator, etc. A power supply generates a signal as does a hot-air gun. You can use the power supply to determine the useable operating voltage of your product and you can employ the hot-air gun to locate temperature sensitive components.

Most often we associate instruments with measuring things. An oscilloscope or voltmeter or logic analyzer are clearly devices that measure electrical properties. Not all instruments are electrical. A scale measures weight, a speedometer measures speed, and a spring measures force. It's useful to remember that there are many non-electrical methods for measuring things. We'll see reasons for this later as we discuss how to design an instrument.

The last class of instruments generate and measure a signal together. The most common instrument of this type is the lowly ohmmeter. It sends a signal (usually a small DC voltage) through the Device Under Test (DUT) and measures the result. There are many variations on this, but the basic idea remains the same for all common ohmmeters. Transistor curve tracers, network analyzers, and in-circuit microprocessor (uP) emulators fall into this category of instruments.

Of course, there are many different approaches for the design of any instrument. One inductance meter may apply a known frequency and measure the actual reactance at that frequency. Another design may simply connect the inductor into an oscillator circuit, measure the frequency, and infer the inductance from that.

Unconventional instruments are often valuable, effective, and inexpensive. A light bulb can be useful as a 60 Hz optical source or as a current limiter or to determine if the light-socket is live. The usefulness of any instrument is only limited by the creativity of the user.

WHAT INSTRUMENTATION REQUIRES

Usually the term instrumentation indicates precision in the generation or measurement of the signal. Of course, different people have different ideas of what precision entails. In the most general sense, virtually everything electronic can be an "instrument." A CD player generates audio signals, the infra-red remote-control receiver on your VCR measures invisible light, and so forth. Your uP software measures digital or analog inputs and generates other digital or analog outputs. It's probably not useful to classify everything as an instrument, even though it could be used as such or because it measures or generates a signal. However, it is indeed useful to understand instrumentation principles whenever you measure or generate a signal.

There are typically two general specifications for all signals: accuracy and resolution. Accuracy references the signal to some standard or accepted value. Resolution specifies the control of the signal. It is extremely important to realize that these are not the same thing. For example, suppose you are operating your uP on batteries and use the internal A/D (Analog-to-Digital converter) to measure a voltage. Let's assume the A/D is eight bits

"Any and all instruments do exactly one of three things. They generate a signal, measure a signal, or generate and measure a signal together."

and the A/D reference is the VCC voltage (in this case the battery voltage) which is the common case. Your A/D measurement is 128 (out of 256) or exactly half-scale. What's the voltage that the A/D is measuring? The truth is that it is unknown. The measurement that the A/D gives depends on the VCC/Reference voltage. If this is 5.0 volts, then the A/D value represents 2.5 volts. If the VCC/Reference voltage is 3.0 volts, then the A/D value represents 1.5 volts. Until you can define the VCC/Reference voltage in relation to a "standard volt," the best you can say is that the signal is one-half of full scale with an error of ±0.39% of full scale. Only when you specify that the VCC/Reference voltage is 5.000 volts can you say that the signal being measured is 2.50 volts ±0.020 volts.

It is often overlooked that the standard three-terminal five-volt regulators have an error of 5% or more. In such an instance, the actual voltage measured could be anything from 2.38 volts (±0.020 volts) to 2.63 volts (±0.020 volts). This example illustrates several points. The first is that the accuracy changes wildly while the resolution (eight-bits) stays the same. The second is that the reference voltage for the A/D must be more accurate than the resolution of the A/D. The third point illustrates an important instrumentation principle: follow your measurement errors all the way back to the source.

If you want better accuracy, you will have to either provide a separate reference voltage or be sure that the VCC voltage is 5.000 volts ±0.4%. Since keeping the VCC supply voltage that precise is very difficult, a voltage reference is usually the chosen solution.

This brings us to another aspect of instrumentation: attention to detail. While this is undeniably important in any aspect of engineering, it is a critical factor in instrumentation. This is seen in the "order-of-magnitude" rule for test and measurement. This rule-of-thumb states that you need 10 times the resolution and accuracy in the instrument for the desired test. If you want to be sure a signal is 1 MHz to within ±10 Hz, you will need a frequency counter that can measure to ±1 Hz. This makes sense once you think about it. If your frequency counter has the same resolution as your measurement, you won't be able to determine if the frequency counter is in error of if the signal is off. There are important exceptions to this (like statistical analysis), but in most normal circumstances, this is a pretty good rule.

This order-of-magnitude rule means that instrumentation design is naturally more stringent and exacting than most common designs. Factors like operating temperature, supply voltage variation and noise, circuit loading, and even things like humidity can be important things to consider. The accuracy of any credible instrument will be able to trace its measurement reference standards back to NIST (National Institute of Standards and Technology). They define what a "standard" volt, pound, foot, and every other unit of measurement is. Their standards must also agree with the rest of the world. Only in this way can everyone, everywhere be sure that they are all measuring the same things.

COMMON-MODE VOLTAGE PROBLEMS

Common-mode voltage is encountered most often with long twisted-pair cables, ungrounded measurements, and low voltages. The situation is that some voltage, of the same magnitude and polarity, is impressed into the two leads going to the measuring instrument. For example, a long twisted-pair cable is likely to act as an antenna or pass by differing magnetic fields, either of which can create a significant common-mode voltage. If you want to measure the current drawn from a power supply, you are likely to use a small value resistor in the high-side line and measure the voltage drop across it (an ungrounded measurement). But the supply voltage is present at both resistor terminals as a common-mode voltage. And when you measure small voltages, there are always other extraneous noise sources that become significant. Being able to deal with common-mode voltages is important.

The basic approach is to use a differential amplifier. A plain op-amp is a differential amplifier, but as we'll see, it needs help. Let's use the playground teeter-totter as a model for the op-amp. Let's say that it's sensitive to a one pound difference. So, if a 35 pound child sits on one end and a 36 pound child sits on the other end, the teeter-totter will not be balanced. Let's place a 35 pound child at each end. It balances perfectly. Now shift the fulcrum (balance point) of the teeter-totter by 0.1%. The 35 pound child on one side will now appear to be 35.035 pounds and the other side will appear to be 34.065 pounds. This very small difference (0.070 pounds) is well below the one pound sensitivity so the teeter-totter will still be balanced.

Finally, let's add a common-mode weight of exactly 1,000 pounds to each side (which is only about 30 times the weight of the child). What happens? Presuming the teeter-totter doesn't break, it will not be balanced. This is because of the 0.1% error of the fulcrum placement. The 1,000 pounds on one side will appear to be 1,001 pounds and the other side will appear to be 999 pounds. The difference is two pounds which is twice the stated sensitivity of the teeter-totter.

With op-amps, this weight is equivalent to voltage. It is important to keep the common-mode voltage perfectly balanced between the two inputs of the amplifier. In order to keep the voltages the same, the resistances into both inputs must also be the same. This is just Ohm's law. This is why multiple op-amps are used to build "instrumentation" amplifiers. It's also why resistor matching is so critical.

Here's a real example. You are tasked to measure the current out of a 35 volt power supply. The current can be as much as 10 amps and it needs to be measured to ±10 mA (0.01 amps). What is the CMRR (Common-

Mode Rejection Ratio) needed and how accurate must the voltage reference be?

Using Ohm's law, it's found that the load resistance at 10 amps and 35 volts is 3.5 ohms. Let's choose a 0.01 ohm sense resistor placed in the high-side (+35 volt lead) and measure the voltage developed across it to determine the current flowing through it (the standard method). Ten amps through 0.01 ohms will create a 0.1 volt signal (and generate one watt of heat so we'll use a five-watt resistor). Using the order-of-magnitude rule, we must measure with 1 mA resolution. This means that if 0.1 volt equals 10 amps, then 10 microvolts equals 1 mA (a factor of 10,000). This 10 microvolts is measured in the presence of 35 volts of common-mode voltage which is a ratio of 3,500,000 or a CMRR of about 131 dB. (This really isn't that hard to do.)

The reference accuracy must be one part in 10,000 or 0.01%. This is defined by the ratio of the smallest measurement (10 microvolts) and the largest measurement (0.1 volts). Note that this includes the order-of-magnitude rule. If you want to digitize this, you will need about 13 bits of resolution (one part in 8,192). Since 13-bit A/Ds are not common, you will have to choose between a 12-bit (one part per 4,096) or 14-bit (one part per 16,384) A/D. The choice will depend on many factors, including cost.

NON-STANDARD INSTRUMENTATION

As time passes, standard techniques are developed for typical instrumentation applications. The analog VOM (Volt-Ohm-Milliammeter) is still a very useful instrument and was once the standard instrument for all engineers, technicians, and hobbyists. Way back then, no one could conceive of anything else. But time passes. With the advent of digital and uP technology, modern multimeters provide capabilities that were once impossible to imagine or realize. It's now common for these inexpensive digital meters to measure capacitance, inductance, frequency, and even test semiconductors. Many times, the traditional methods work well. There is certainly a lot of history and experience associated with them. But it's always useful to look at new ways, too. It is not uncommon for standard instrumentation practice to lag behind technical advances. And naturally, creativity can always be applied. Let's look at a couple of examples.

A common requirement is the generation of a low-distortion sine wave. There are lots of ways to do this. There are analog methods like the Wien-bridge oscillator (made famous by H/P), L-C oscillators, crystal oscillators, phase-locked-loops, etc. The digital method typically uses a D/A (Digital-to-Analog converter) to create the sine wave in steps. There are a number of variations of this method which include the NCO (Numerically-Controlled-Oscillator). Don Lancaster has spent considerable time generating special digital patterns that can be easily filtered to create "magic sine waves."

However, there is another method that seems neglected: switched-capacitor filters. These devices use a combination of analog and digital techniques to create "universal" filters of nearly any type (Butterworth, Bessel, Elliptic, etc.) and of high-order (very sharp response). It's very easy to create (or buy) a sharp-cutoff low-pass filter with a stop-band only 100% higher than the pass-band. This means that if you put a square wave into the filter with a frequency near the high edge of the pass-band frequency, the higher harmonics are filtered out, leaving a nice, digitized sine wave. There are typically 50 or 100 steps in the sine wave (due to the digital clock of the filter). These are easily filtered out with a simple R-C filter. But wait! There's more!

The cutoff frequency of the filter is locked to the clock frequency. This means that if you use a derivative of the clock as the input square wave, the output sine wave will track perfectly with the clock. You have a very simple and inexpensive sweepable, sine wave generator that can be digitally controlled. Since it's a filter, rather than an oscillator, the output amplitude is very stable. Since it's based on a digital clock, the frequency is extremely stable. In short, the switched-capacitor-filter is a very useful sine wave generator.

MEASUREMENT CONVERSIONS

It is often very useful to convert a difficult-to-measure property into something that is easier to measure. As we saw in the above current-measuring exercise, we converted a current into a voltage by using a "sense" resistor. It's hard to measure current directly. Even analog meters convert current into a magnetic field to deflect a pointer. Measuring current directly means counting electrons. I'm sure that's possible, but I'm also sure that it's not practical for most applications. Whenever you are tasked to measure something difficult, it's often useful to stop and think of as many different conversions as you can.

Let's look at a real example. A while back, I worked for a company that made gravimeters (a device that measures local gravity with high precision). They wanted a "New Method." The old method was actually very sensitive and used a coil of wire held between magnets with an electric current. The position of the coil was measured capacitively. There were two problems. The magnets changed their magnetism over time and the "spring" that supported the coil also changed over time. With gravimeter sensitivity in the parts-per-million range, it took very little change in these parts to create a significant measurement change. In fact, the rate of change for these parts was measured and applied to all measurements. A workable, if not elegant, approach.

I let the problem roll around in my head for a few weeks. I realized that we could measure time with fantastic accuracy. Was there a method

of converting gravity to time? It was certainly possible to measure the time it takes for something to fall, but others had taken this approach with only fair success. I wanted a method to continuously convert gravity to time. Finally, there was an answer. Take a vertical rod with a string and weight attached to the top. Rotate the rod and the weight will move outward because of centrifugal force (AKA inertia). When the string is at exactly 45 degrees, the rotation rate creates enough force to exactly balance the local gravity. Measuring a fixed angle with high precision is not too difficult. Timing the speed of rotation is also something that can be done with great precision. And there were no springs or magnets to change over time. Too bad that the company fell apart before it could be built. (Note: the rod and ball description is only conceptual. The actual "Centrifugal Balance" design is very different. Also, if you are seriously interested in measuring gravity or the gravitational constant, let me know.)

The point of this is to show that there are many different ways to measure the same thing. Just because somebody does it one way does not mean that it is the best or only way. Think about the task and examine it from as many angles as you can. A little creativity can solve some big problems.

NEW METHODS

Naturally, if you do conceive of a new method of measuring something, there will usually be resistance. Not all of this is unfounded. The traditional methods have worked well for a long time. How can you be sure that your new method will work? And if it does, how can you know that it will be as effective as the old way? Quite honestly, until you actually realize the instrument these questions cannot be directly answered. However, they can certainly be addressed. This is done with an error analysis.

Very briefly, an error analysis is a detailed examination of the characteristics of the instrument. It's based on a paper design with real parts. The proposed method is defined according to the performance of these parts. If the method does not exceed the performance of the individual parts, and if the error sources (like noise, etc.) are manageable, then the new method should be workable.

CONCLUSION

Instrumentation is fundamentally the measurement and generation of signals, typically of high precision and accuracy. We've briefly touched on some of the basic principles and examined some practical examples. Since virtually all of electronic design requires the generation and measurement of signals, having a basic understanding of instrumentation can be useful and have a wide application. **NV**

TECH FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nutsvolts.com All *diagrams should be computer generated and sent with your submission as an attachment.*

QUESTIONS

To be considered, all questions should relate to one or more of the following:

1. Circuit Design
2. Electronic Theory
3. Problem Solving
4. Other Similar Topics

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Include your Name, Address, Phone Number, and email. Only your Name, City, and State will be published with the question, but we may need to contact you.
- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions are subject to editing.

ANSWERS

- Include in the subject line of your email, the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address or we cannot send payment.
- Only your Name, City, and State, will be printed, unless you say otherwise. If you want your email address included, indicate to that effect.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

We had a large RadioShack antenna with a rotator on our roof for more than a decade which worked well. We have done some remodeling and decided, while we had it down, to replace it. So, last Fall, we put up a new RadioShack long range VHF/UHF VU-190 antenna and rotator.

The new equipment worked adequately all Winter (but never quite as good as the old one). Around April or May, I noticed that the reception for the higher numbered UHF channels seemed to be getting worse. During Summer, TV watching was a very low priority, but, this problem seemed to continue to worsen.

Thinking about it carefully now, last Fall we got good to fair reception on channels 36 and 29 and excellent reception on channels 23, 19, and 17. Now it has changed to fair reception on channel 23 and passable on 17. All the others are basically unusable. Clearly, something has changed as the temperature and weather are similar now to when the antenna was installed.

The antenna has a matching transformer connected to RG-59 coax cable mounted directly to it and potted in RTV. The RG-59 leads directly to the basement and is connected by a grounding block to a water pipe for lightning arresting. From there, it goes to a distribution amplifier and on to the TVs.

VHF reception has not changed since installation and remains very good. The antenna and cabling appear good and show no obvious effects of weathering or other factors. Any ideas in locating and curing this problem would be greatly appreciated.

#2061 Bill Rauch, Hamburg, NY

I am looking for an easy build it yourself receiver to pick up the 60 kHz signal from WWVB. I live in the Pittsburgh, PA area and I have a few atomic clocks that never receive the updates for some reason. I would like to hear or at least see the pulses via an LED indicator just to see if the signal is really there. Any ideas from the forum?

#2062 Joe Reed, Pittsburgh, PA

I have a 30mm mechanical watch that has, unfortunately, become magnetized. Will the Velleman mag/demag work to remove the magnetism? Also, is the slot large enough to accomodate a 30mm watch?

#2063 Robert Jacobs, via Internet

>>>> ANSWERS

[#11058 - November 2005]

I am using an Apple Macintosh CRT Studio monitor coupled to a desktop PC.

There is some "squiggle" through-

out the presentation on the CRT face. By this, I mean a kind of subtle wavy action in the picture appearing to run vertically. It is most noticeable with text but can be detected in any kind of graphic along the borders of a given object.

I have consulted "Troubleshooting and Repairing Computer Monitors" by Stephen J. Bigelow. The closest I can deduce from consulting this publication is the capacitors in one of the power supplies are aging and will need replacement. I was considering opening the monitor's case and "shotgun" replace all large capacitors in sight, but this will probably be a fool's errand.

Another possibility mentioned in the book is the shielding around the video cable may be nicked or kinked, but the cable appears intact. Can anyone offer some other ideas or a better rationale for isolating the problem?

"Squiggle" or wavering of a CRT image is often caused by magnetic interference. I have seen a cheap "wall wart" (plug-in power brick) power supply cause noticeable interference from over four feet away. Make sure all transformers and motors (and fluorescent lamp ballasts) are far away from your monitor. I also once tracked down a very peculiar case of the monitor jitters to the fluorescent ceiling light wiring in the room downstairs - it took a call to the building electrician to fix it.

Robert Zusman, Scottsdale, AZ

[#12053 - December 2005]

I have a control arm that moves up and down, pulling a cable. I would like to place in a remote site, a series of LEDs that indicate the position of the arm. How can I convert the movement of the cable or arm to activate the LEDs in relation to the arm/cable?

#1 It is difficult to design instrumentation for such an application without more definition of the nature of the motion and the dimensions involved, i.e., Is the motion of the control arm an arc or is it linear? Are we talking about inches of movement

Okay, let's try this one again.

Editor

[#12052 - December 2005]

I have some 4559 aircraft landing lights, they are 28 volt 600 watt. I was hoping to use them for some concert lighting I do. But, I haven't come up with a way to power them, being that I need a 28 volt 21.5 amp power supply (I assume AC or DC will work).

I tried an off-the-shelf standard home dimmer, carefully setting it (low) to 12V-15V, but it just blew the bulb.

I work in the theatrical lighting industry and we use these lamps all the time. They are a PAR 64 (paraboic reflector) lamp and should be used in a suitable housing (Par Can) since they get very hot, very quickly. These are very narrow spot type lamps and throw an amazing amount of light. The way we use them is to make a "series 4-fer", i.e., wire four of them in series and then use conventional 110-120 volt dimming systems for them. You might want to set your dimmers for these to only go to about 90% of full voltage to keep from blowing these bulbs. One other thing I like to do when wiring these and when constructing the series harnesses is to provide a small LED at each lamp wired in such a way as to light the LED only when the lamp in question fails to complete the circuit. Just put an LED at each point in the circuit where failure to complete the circuit causes the LED to light. This makes troubleshooting a breeze when you lose a lamp. This is not absolutely necessary for the operation of these lights. Very often, since this is a series circuit, over-voltage will blow all lamps on the 4-fer, so regulating the voltage to an absolute maximum of 112 volts is imperative (28V x 4 = 112V). A standard 2.4KW theatrical dimmer is capable of handling one string of these ACLs (600W x 4 = 2.4KW). Setting the profile of a theatrical electronic dimmer to 90% gives the following: 120V x .90 = 108V. So when you "go to full," you are actually staying below the blowout threshold. If you need the Par Cans for these, I would recommend eBay — search for UL approved PAR 64 fixtures and you will be all set. These fixtures usually come with a porcelain base for other types of PAR lamps; the lamps you have use screw terminals. The bases can be removed easily and I would recommend crimping on uninsulated fork or ring stakons of the proper size for the screws (#8) and for the wire (usually #16 or #14).

David Shepherd
New York, NY
daveshep@earthlink.net

I just read the reply to the question about running an aircraft landing light at home and found it hard to believe it made it past the editors.

The first part is way off base. The reason the lamp blew is that a dimmer doesn't actually control the voltage but, in effect, the duty cycle of 170V peak pulses. To the dimmer, the cold filament in that lamp will appear as a nearly direct short and I would expect it to blow the triac in the dimmer, as well as the lamp.

The second part of the reply is just plain wrong. The lamp in question is incandescent. While in its original application it would be run on DC, it is not a "DC only lamp" but will work equally well on AC.

I can offer a viable solution: modify an old microwave oven transformer. These are readily available in junked ovens and are often rated as high as 1KW. To convert one, simply cut away the old (and dangerous!) high voltage winding without damaging the primary and carefully wind enough turns of #10 insulated wire around the core to achieve the desired output voltage. It will take some experimentation, but if you wind a couple turns around it, apply power, and measure the output voltage of your new winding, you will know the approximate voltage per turn and can calculate the necessary number of turns accordingly. Good luck!

James Sweet
via Internet

or feet?

A simple solution is to attach a magnet to either the arm or cable and locate reed switches so that the magnet moves by them thus closing their contacts. The number of reed switches would be determined by the resolution required of the readout. This approach has the advantage of not putting any load on the arm or cable.

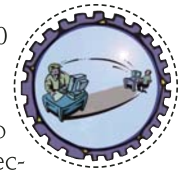
If the motion is just a few inches, one could attach the slider of a linear slide potentiometer to the control arm (or a regular potentiometer to the shaft if the control arm rotates) and read the position with a voltmeter. The potentiometer would be wired as a voltage divider. This has the advantage that it would require only two wires to the remote location rather than the number of wires for multiple LEDs.

James Schmidt, Deer Lodge, MT

#2 There are several different ways this can be accomplished. Each method has benefits or disadvantages, so let's start with the simplest one:

A. Analog feedback method: A potentiometer is coupled to the arm and provides a voltage signal to a follower for signal conditioning (low output impedance) and is then fed to a variable current source. You can find these circuits in any good Op-amp Cookbook with the necessary explanations. The current signal is then dropped across a resistor on the other end and you will have a voltage signal to work with. Another follower with a few comparators will give you the signals for the LEDs or you can use a digital or analog instrument. A signal of 0/4-20 mA is commonly used. This has the advantage that cable length is not an issue and the remote circuit (transmitter) needs only two wires if carefully designed.

B. Simple digital feedback method: A quadrature encoder is used at the arm with an optional index hole. This is typically a disk with a series of slots and two slotted optical switches, slightly shifted so that one activates before the other.



The shift is exactly 90 electrical degrees (therefore its name) and allows the steps to be counted in both directions. You can find this type of circuit in any mouse (there are actually two circuits in a mouse for X and Y direction, but no index) or on motion control systems. The index hole with its own optical switch serves to determine a home position. A microcontroller counts the steps and transmits the signal serially to another micro to turn on the appropriate LEDs. There is good literature up on Microchip's website (AN894) and on National Instrument's website.

C. Digital feedback with an absolute encoder: An encoder to provide position in binary or gray format is connected to the arm and then transmitted to the remote site and used to display the position. This could be as simple as a three-bit (giving you eight different positions) or as complex as necessary.

Walter Heissenberger, Hancock, NH

AD INDEX

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PowerSupply1 Switching Power Supplies

New to **CircuitSpecialists.com** are these Highly Reliable, Universal AC input/full range single output power supplies. Choose between various 40, 60, 100 & 150 Watt versions. They have the approval of UL and cUL and come 100% full load burn-in tested and are protected with overload/over and voltage/short circuit. Also included is a 2 year warranty.

PowerSupply1	Qty 1	Qty 10	Qty 25	Qty 100	Qty 500	Qty 1000
40W Series Available in 5,12,15,24,48V	$28.99	$26.09ea	$24.53ea	$21.95ea	$15.98ea	$13.79ea
60W Series Available in 5,12,15,24,48V	$32.99	$29.69ea	$27.91ea	$25.95ea	$17.69ea	$15.49ea
100W Series Available in 3.3,5,7.5,12,15,24,48V	$38.50	$34.65ea	$32.57ea	$29.99ea	$21.18ea	$18.49ea
150W Series Available in 5,7.5,9,12,24,28,36V	$48.99	$44.09ea	$39.00ea	$37.50ea	$26.93ea	$23.49ea

Programmable DC Power Supplies

NEW!

The CSI 3600 Series Programmable DC Power Supplies are equipped with a back-lit LCD display, number keypad and a rotary code switch for ease of use & quick programming. Voltage, Current & Power can all be displayed on the LCD or computer screen (with optional RS-232 interface module). It can be operated at constant current mode, constant voltage mode & constant power mode. It also can be set with maximum limits for current & power output. Ideal instruments for scientific research, educational labs or any application requiring a sophisticated DC-power source.

Model	CSI3644A	CSI3645A	CSI3646A
DC Voltage	0-18V	0-36V	0-72V
DC Current	5A	3A	1.5A
Power (max)	90W	108W	108W

Only $199.00 Each!

www.CircuitSpecialists.com

Programmable DC Electronic Loads

The CSI 3700 series electronic loads are single input programmable DC electronic loads that provide a convenient way to test batteries and DC power supplies. It offers constant current mode, constant resistance mode and constant power mode. The backlight LCD, numerical keypad and rotary knob make it much easier to use. Up to 10 steps of program can be stored.

NEW!

Model	CSI3710A	CSI3711A
Input Voltage	0-360V DC	0-360V DC
Input Current	0-30A DC	0-30A DC
Input Power	0-150W	0-300W

CSI3710A: $349.00 **CSI3711A: $499.00**

Circuit Specialists Soldering Station w/Ceramic Element & Seperate Solder Stand

$34.95!

- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
- 3-prong grounded power cord/static safe tip
- Seperate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

Item# CSI-STATION1A

Rapid Heat Up!

Also Available w/Digital Display & MicroProcessor Controller

Item# CSI-STATION2A

$49.95

Details at Web Site

SMD Hot Tweezer

Adaptor Fits **CSI Stations 1 & 2**, and also **CSI906**

$29.00

Item# CSITWZ-STATION

> Soldering Equipment & Supplies > Soldering Stations

In Business
Circuit Specialists Inc.
Since 1971

Bullet Style B/W Camera

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" **LG CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-305

1-4:$49.00 5+:$46.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

Heavy Duty Regulated Linear Bench Power Supplies

NEW!

- Multi-loop high precision voltage regulation
- Automatic voltage & current stabilizing conversion
- Automatic radiant cooling system
- Over-heating protection

CSI5030S: 0-50v/0-30amp **$595.00**
CSI12005S: 0-120v/0-5amp **$595.00**
CSI20002S: 0-200v/0-2amp **$595.00**

Details at Web Site

> Test Equipment > Power Supplies

High Capacity Nickel Metal Hydride Rechargeable Batteries

Item#		1+	10+	100+
AA2500mAH	"AA" cell 2500mAH	$1.45	1.25	1.09
AAA850MAH	"AAA"cell 850mAH	$0.99	0.65	0.51
C3500MAH	"C" cell 3500mAH	$2.99	2.30	2.09
D11000MAH	"D" cell 11000mAH	$6.95	5.55	4.39
9V220MAH	"9V" cell 220mAH	$3.69	3.29	2.99

Details at Web Site

> Batteries & Accessories > NiMH Batteries

Dual Output DC Bench Power Supplies

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

As Low As $93.00!

- Source Effect: $5x10^{-4}$=2mV
- Load Effect: $5x10^{-4}$=2mV
- Ripple Coefficient:: <250uV
- Stepped Current: 30mA +/- 1mA

HOT ITEM!

*All 3 Models have a **1A/5VDC Fixed Output** on the rear panel*

CSI3003X-5: 0-30v/0-3amp 1-4: **$97.00** 5+: **$93.00**
CSI5003X5: 0-50v/0-3amp 1-4: **$107.00** 5+: **$103.00**
CSI3005X5: 0-30v/0-5amp 1-4: **$119.00** 5+: **$115.00**

Details at Web Site > Test Equipment > Power Supplies

Triple Output Bench Power Supplies

with Large LCD Displays

Output: 0-30VDC x 2 @ 3 or 5 Amps & 1ea. fixed output @ 5VDC@3A
Source Effect: $5x10^{-4}$=2mV
Load Effect: $5x10^{-4}$=2mV
Ripple Coefficient: <250uV
Stepped Current: 30mA +/- 1mA
Input Voltage: 110VAC

CSI3003X3: 0-30VDCx2 @3A **$179.00** 5+: **$169.00**
CSI3005XIII: 0-30VDCx2 @5A **$219.00** 5+: **$209.00**

NEW!

Details at Web Site > Test Equipment > Power Supplies

Premier Repairing System w/Power Supply

Microprocessor controlled design that provides stability and precision of temperature and airflow settings during the rework process. A full digital display of temperature and power source make everything clear to the user while the unit provides vast flexibilty at the rework station with the built-in adjustable power supply that provides 0-15V and 2A of power. Hot air soldering and adjustment of temperature are controlled by a micro chip and sensor thus giving tremendous accuracy and reliability.

Item# CSI768

Only $289.00!

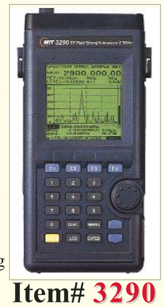
- Iron Output Voltage: 24V / 35W
- Temperature Range: 100-480°C / 212-896°F
- DC Power Supply: 0-15V / 2A

Details at Web Site > **Soldering Equipment & Supplies**

2.9GHz RF Field Strength Analyzer

Fantastic Low Price: $1899.00!

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz.The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RF transmissions.



Item# 3290

- WFM/NFM/AM/SSB modulated signals may be measured.
- Signal Levels up to 160Channels can be displayed simulaneously on the LCD
- PLL tuning system for precise frequency measurement and tuning
- Built-in Frequency Counter
- LED Backlight LCD (192x192 dots)
- All fuctions are menu selected.
- RS232C with software for PC & printer interface
- Built-in speaker

(Includes Antenna)

Details at Web Site > **Test Equipment > RF Test Equipment**

B&W Pinhole Bullet Camera w/ 1/3" CCD

- Weather Resistant Housing
- Signal System: EIA
- Image Sensor: 1/3" CCD Bullet Hole
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-305CP

1-4:$49.00
5+:$46.00

Details at Web Site
> Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

LogicPort Logic Analyzer

$369.00!

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

Item# LOGICPORT

Details at Web Site > **Test Equipment > Logic Analyzers**

Butane Portable Soldering Iron & Kit

NEW!

- Electronic Instant Ignition System
- Naked Flame Burner: Temp to 1300°C/2370°F
- Flameless Burner: up to 400°C/750°F

Two-Piece Iron comes with Solder Tip.

RK3212: Solder Iron $14.95

- Equipped with U.S.CPSC Approval Child Safety Standard
- Electronic Instant Ignition System
- Naked Flame Welding: Temp to 1300°C/2370°F
- Soldering Temp: up to 500°C/930°F
- Heat Shrinking: up to 500°C/930°F
- Hot cutting of plastic sheets or plates

RK3124: Solder Kit $34.00

Details at Web Site > **Soldering Equipment & Supplies > Soldering Irons**

Plug-In Switching Power Supplies

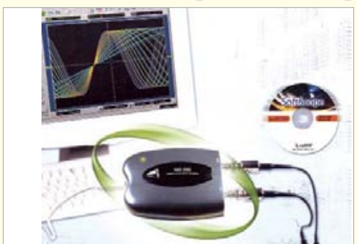
These **15W** switching power supplies are an inexpensive way to power devices with robust regulated power and low ripple noise. The low-profile design allow you insert them into a power strip without losing any of the other plugs. Designed with an energy efficient switching technology, the **Universal AC input works from 90-264VAC** with no minimum load required and a 100% burn-in test to ensure they will perform as stated right out of the box. They come with a 1.8 meter output cord and a 5.5 x 2.1mm female plug. UL and cUL approved.

Item#	Description
3A-161WU05	5 Volts / 2.6 Amps
3A-161WU06	6 Volts / 2.5 Amps
3A-161WU09	9 Volts / 1.70 Amps
3A-161WU12	12 Volts / 1.25 Amps
3A-161WU18	18 Volts / 0.84 Amps
3A-161WU24	24 Volts / 0.63 Amps

Each	10+	25+	100+
$9.95	$8.95	$8.49	$6.95

Details at Web Site > **Test Equipment > Power Supplies**

Digital Storage Oscilloscope Module



PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC basedscope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software Download at Web Site

SALE!

> **Test Equipment** > **Oscilloscopes/Outstanding Prices**

Item# 200DSO Only $829.00

SONY Super HAD CCD™

equipped camera's feature dramatically improved light sensitivity

SONY Super HAD CCD Color Weatherproof IR Cameras

480 TV Lines Resolution

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# VC-827D 1-4:$149.00 5+:$139.00

SONY Super HAD CCD B/W Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# VC-317D 1-4:$69.00 5+:$65.00

SONY Super HAD CCD Color Camera

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# VC-805 1-4:$69.00 5+:$65.00

SONY Super HAD CCD Color Weatherproof IR Camera

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" **SONY Super HAD CCD**
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# VC-819D
1-4:$89.00 5+:$79.00

SONY Super HAD CCD Mini B/W Board Camera

- Signal System: EIA
- Image Sensor: 1/3" **SONY Super HAD CCD**
- Horizontal Resolution: 420TV Lines
- Min. Illumination: .05Lux/F1.2

Item# VC-103 1-4:$33.00 5+:$29.00

Details at Web Site
> **Miniature Cameras(Board,Bullet,Mini's, B/W, Color)**

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ **www.CircuitSpecialists.com**. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors,miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more! ***Some Deals you won't believe!***